Potato Production in the Northeastern and North Central States

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POTATO production may be classed as early, intermediate, and late, depending upon the time of harvest. The late, or main, crop comprises about four-fifths of the total potato production of the United States. It is, therefore, of much greater economic importance than the early and intermediate crops combined. Approximately two-thirds of the late crop is stored in the fall and used as needed during winter and spring.

The late crop is grown chiefly in the northern tier of States because of favorable climatic and soil conditions. The potato grows best where the mean temperature during the summer is relatively low, generally not exceeding 70° F., and where ample moisture is available during the growing season. Many areas having suitable climatic and soil conditions are found north of the thirty-ninth parallel from the Atlantic coast to the Pacific. These two factors largely determine the extent of the crop in any given State.

The late-crop potato industry in the States discussed in this bulletin is a highly specialized one. It is concerned with the production of potatoes for consumption, so-called table stock, and for seed stock. The production of maximum yields of good-quality table stock requires attention to essential details on the part of all growers; the production of healthy seed stock (certified) requires even greater attention if success is to be attained. Approximately three-fourths of the entire late crop of the United States is produced in the Northeastern and North Central States, and nearly 85 percent of the total certified-seed production can be credited to these States.

The purpose of this bulletin is to discuss various factors affecting potato production, including the soil and its preparation; planting operations and subsequent cultural care of the crop; use of fertilizer, lime, and manure; irrigation; varieties; care and treatment of seed tubers; diseases and insects; spraying; harvesting; and storing.

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POTATO PRODUCTION IN THE NORTHEASTERN AND NORTH CENTRAL STATES

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EXTENT AND VALUE OF THE POTATO CROP

POTATO crops are classified according to time of harvest as early, intermediate, and late. The late, or main, crop comprises about 78 percent of the total production of the United States. Approximately

two-thirds of this is stored in the fall for use during winter and spring. The late crop is grown chiefly in the northern tier of States, about three-fourths of it in the Northeastern and North Central States (1940–46 average). Nearly 85 percent of the certified seed also is produced there.

The acreage harvested, production, yield per acre, and value of potatoes from 1940 to 1946 for the 21 States covered by this bulletin are given in table 1. It will be noted that 8 of these States produced on an average more than 10 million bushels. The acreages harvested, however, were great. Minnesota, with an average acreage harvested of 200,000 acres, led all States in the group. It was followed by New York, Maine, Michigan, Pennsylvania, North Dakota, Wisconsin, Ohio, New Jersey, and Iowa. The highest average acreage yield (296 bushels) for this period was obtained in Maine and the next highest (193 bushels) in Rhode Island.

TABLE 1.—*Acreage, yield per acre, production, price per bushel received by farmers, and value of potatoes in the 21 Northeastern and North Central States*

[7-year average, 1940–46 [1]]

State	Acreage harvested	Acre yield	Production	Average price per bushel received by farmers	Value
	1,000 acres	*Bushels*	*1,000 bushels*	*Dollars*	*Dollars*
Maine	186	296	55, 056	0. 99	54, 505, 440
New York	193	160	30, 880	1. 25	38, 600, 000
Pennsylvania	156	124	19, 344	1. 37	26, 501, 280
Michigan	180	105	18, 900	1. 17	22, 113, 000
Wisconsin	151	86	12, 986	1. 14	14, 804, 040
Minnesota	200	95	19, 000	1. 00	19, 000, 000
North Dakota	156	124	19, 344	. 90	17, 409, 600
South Dakota	33	80	2, 640	1. 15	3, 036, 000
West Virginia	32	97	3, 104	1. 48	4, 593, 920
Ohio	77	111	8, 547	1. 51	12, 905, 970
Indiana	40	112	4, 480	1. 35	6, 048, 000
Illinois	30	85	2, 550	1. 50	3, 825, 000
Iowa	44	103	4, 532	1. 36	6, 163, 520
New Hampshire	7	160	1, 120	1. 49	1, 668, 800
Vermont	12	137	1, 644	1. 48	2, 433, 120
Massachusetts	21	144	3, 024	1. 48	4, 475, 520
Rhode Island	6	193	1, 158	1. 44	1, 667, 520
Connecticut	18	178	3, 204	1. 46	4, 677, 840
New Jersey	64	175	11, 200	1. 13	12, 656, 000
Kansas	23	91	2, 093	1. 08	2, 260, 440
Missouri	36	102	3, 672	1. 15	4, 222, 800

[1] The data were obtained from the Bureau of Agricultural Economics, Crop Reporting Board.

CLIMATIC AND SOIL REQUIREMENTS

The potato is a cool-climate plant which grows best in regions where the mean summer temperatures are relatively low, generally not exceeding 70° F., and where ample soil moisture is available during the growing season. Adequate moisture is especially important from the time tubers begin to form until slightly before harvest. In the region

north of the thirty-ninth parallel from the Atlantic coast to the Pacific are many areas where climatic and soil conditions, the two factors that largely determine the size of potato crops, are both suitable.

Among the best soils for potatoes are well-drained, sandy, gravelly, or shale loams and loams well-supplied with organic matter and available plant food. Part of the crop in Indiana, Iowa, Michigan, Minnesota, New York, Ohio, and Wisconsin is, however, produced on muck and peat. Such soils when well drained and properly fertilized are usually capable of producing good yields of high-quality potatoes. Heavier soils also are satisfactory provided they are adequately drained and their organic-matter content is maintained.

Certain soils should be avoided because they lack the necessary physical and chemical qualities or are infested with disease-producing organisms. Soils that are neutral or alkaline or that have produced many scabbed tubers are likely to produce diseased potatoes. Heavy, poorly drained clay and clay loam having tight subsoil and poor tilth are also likely to produce small crops of ill-shaped, poor-quality tubers. Premature ripening of vines and consequent reduction in yield occur also on deep sandy soils that tend to blow, are subject to leaching, or possess low water-holding capacity.

CROP ROTATION

No general recommendations can be made about crops to be grown in rotation with potatoes, as these vary from place to place. In the New England States, in northern New York, and in Michigan, Wisconsin, and Minnesota a 3- to 5-year rotation is generally practiced; in this the clovers play an important part. In a 3-year rotation the potato crop is followed by grain in which clover and grass are seeded. The first cutting of clover is usually made into hay, whereas the second growth is turned under in the late summer or early fall. In the corn country the order of rotation is usually clover, corn, and potatoes. In certain sections, including Long Island, N. Y., Ohio, and the Corn Belt generally, where the early potato crop is harvested before September, it is a common practice to seed rye as a winter cover crop immediately after the potatoes are dug. Where alfalfa is grown a longer rotation is required, as it takes 2 years to get an alfalfa crop well established. For details as to the rotation best suited to local conditions consult the county agricultural agent.

SOIL PREPARATION AND IMPROVEMENT

PLOWING AND FITTING THE LAND

In general, land should be plowed in late summer or early fall for the late-potato crop (fig. 1). This holds for green-manure crops, such as the combination of oats, peas, and vetch, as well as for clover and alfalfa sod. Fall plowing facilitates decay of the sod and exposes the soil to the natural weathering processes during the winter months. The depth to plow depends largely on the depth of the surface soil and the character of the subsoil. A deep and fertile surface soil should be plowed to a depth of 10 inches or more; a shallow soil should not be plowed more than an inch deeper than the plow depth. A 14-inch plow or larger is necessary to do a good job of plowing for potatoes.

Figure 1.—Plowing under clover for the potato crop.

Figure 2.—Disking land in preparation for planting potatoes.

If much trash is to be turned under, plows with 16- and 18-inch bottoms and with a large clearance are needed. Fields with a decided slope should be strip-planted, and in most cases the plowing should be done in very late fall or in the spring to prevent undue erosion.

Fall-plowed land should be disked the following spring as soon as the land is dry enough to work (fig. 2). Disking pulverizes the soil, reduces large air pockets, and keeps the seedbed firm. On most potato soils the disk harrow should be followed by the spring-tooth harrow (fig. 3). It penetrates the soil deep enough to tear up clods, and the flexible teeth suffer little damage from stones or other obstructions. On some fields it may be necessary to use the spike-tooth harrow to break clods and level the ground. Such a harrow is also effective in covering small weeds.

Figure 3.—The spring-tooth harrow in operation.

DRAINAGE AND PREVENTION OF SOIL EROSION

Unless a soil is naturally drained, it should be drained by artificial means before potato growing is attempted. Excess water in the soil fills the pore spaces and excludes air, so necessary for bacterial decomposition of organic materials and for certain vital chemical reactions. Seed pieces often rot, and poor stands and reduced yields result. Root development is generally retarded. Poorly drained, heavy soils in particular are difficult to get in shape for planting and produce tubers of poor shape and quality.

Prevention of soil erosion cannot be too greatly stressed. Any waste of topsoil ultimately means a serious loss of capital to the potato grower. Fortunately, in recent years Federal, State, and county agricultural agencies have combined in a Nation-wide battle against soil erosion.

The Soil Conservation Service, United States Department of Agriculture, is cooperating with farmers in all parts of the United

States in demonstrating effective, practicable soil-conserving practices and methods. In checking erosion a complete diagnosis is essential before appropriate preventive remedies can be prescribed to correct the trouble. In view of the fact that erosion losses are due to diverse causes, it is obvious that no one remedy can be construed as a cure-all. For this reason, any potato grower who is confronted with an erosion problem should seek the advice of his local soil conservation agency.

BUILDING UP THE ORGANIC-MATTER CONTENT

One of the most important soil problems in practically all potato regions, except those with muck and peat, is that of soil organic matter. In regions with long seasons the decomposition of organic matter is almost continuous; in colder regions it is less rapid in summer and does not occur appreciably during the winter. An ample supply of decaying organic matter helps to keep the soil loose and mellow and thereby prevents packing. Organic matter also facilitates plowing and cultivating; it enables roots of potato plants to penetrate the soil more readily and retains rain water; it insures food energy for the growth of desirable soil micro-organisms; and it supplies plant food. These conditions enable potato tubers to develop better and to maintain their normal shape; shape is an important consideration in marketing the crop.

Each potato farm must ordinarily produce its own organic-matter supply. There are four general methods of getting organic matter into the soil: (1) Adopting a suitable rotation in which a leguminous crop such as clover or alfalfa is grown; (2) growing and plowing under green-manure crops (including catch and cover crops), such as crimson clover,[1] vetch, or a combination of peas and vetch, soybeans, cowpeas, rye, oats, barley, wheat, millet, Sudan grass, field corn, or other suitable crop plants; (3) applying barnyard manure; or (4) plowing under any other organic refuse that will increase the humus content of the soil.

Barnyard manures improve the physical condition of the soil, add plant food, and increase the bacterial activity. Manure should be carefully conserved so as to prevent as much as possible the loss of valuable nutrients. It should never be piled loosely in the open yard or allowed to accumulate under the eaves of the barn, because both methods permit leaching of valuable plant foods. The valuable constituents can be retained by keeping the manure moist and compact. If left in the open the pile should have a slightly concave top and nearly straight sides. It should be kept moist throughout to avoid excessive heating, for, if the pile is allowed to dry out too much, firing results. To be used most efficiently for potatoes, manure, particularly when fresh, should be hauled directly to the field and spread uniformly on sod land before fall plowing. A manure spreader does the job very effectively. Succeeding rains will wash the soluble plant food into the soil. On sloping land the manure should be spread just before the plowing is done.

Light applications of manure are better than heavy ones. Make the manure cover as many acres as practicable; 60 tons is better on 10

[1] If weeds are prevalent where crimson clover or crops with similar habits are grown, there is danger of increasing the weed hosts of aphids and thus making the aphid problem worse. (See p. 56.)

acres than on 5. Generally it is considered a good practice to add 40 to 50 pounds of ordinary superphosphate to each ton of manure. However, where complete fertilizer is used in addition to the manure this treatment assumes less importance.

Fresh manure should not be applied just before the potato crop is planted, as it may produce a favorable environment for common scab development, particularly if the soil is not sufficiently acid in reaction. There is less danger on soils having a pH [2] of 5.0 than on those having a pH near 6.0. The best rule to follow in the use of fresh manure is to get it plowed under as soon as convenient, so that it will decay before the crop is planted.

LIMING

Liming is an important factor in potato production. When the soil is too acid the clover, or other soil-improvement crop in the rotation, begins to thin out and bare spots appear here and there in the fields. The question that concerns all potato growers, however, is how much lime to apply to help the clover but not increase the common scab on the potatoes. Where there is insufficient lime the clover suffers, but when there is too much lime common scab is apt to develop. Common scab is caused by a soil-borne organism (*Actinomyces scabies* (Thaxt.) Güssow). Its development is promoted by alkaline or mildly acid soil reactions. Increasing the soil acidity will usually check the development of the organism to a point where only clean tubers are obtained. The addition of too much lime to most soils, except very acid ones, generally favors its development. Too much acidity (below pH 5.0) is undesirable, and that above pH 5.5 may favor scab. The grower should obtain information about the lime requirement of his soil from the local soil-testing services available.

Effective ways of using lime in potato rotations have been found, and as a result clover does well and common scab is held in check. In Aroostook County, Maine, potato growers have greatly increased their use of liming materials. Beverly,[3] writing on the subject, states:

> Success in growing green-manure crops is closely associated with intelligent liming practices. The use of lime has increased rapidly in Aroostock. In 1926, 200 tons of ground limestone were applied; in 1930, 5,000 tons of lime; and in 1940, about 15,000 tons. Under the materials program of the Agricultural Adjustment Administration, the use of lime increased rapidly. In 1944, 25,000 tons were used; in 1945, 39,000 tons; and in 1946 an estimated 45,000 tons of ground limestone will be used by Aroostook farmers in their potato rotation.
>
> In liming potato soils two points must be considered: (1) The effect upon the growth of clover or other green-manure crops, and (2) the effect upon common scab infection. In general, on fields that have in the past given poor clover stands and that did not scab the last time they were planted in potatoes, applications of 1,000 to 1,500 pounds of ground limestone per acre before seeding will be found necessary for a good catch of clover. When soils are less acid, smaller applications are recommended to avoid scab infection. The initial liming requirement on short rotations will be somewhat greater than will successive applications.

[2] The pH value is the most common term now used to express the degree of acidity or alkalinity. It is simply a numerical expression denoting the acidity or alkalinity. A neutral soil has a pH value of 7; values above 7 denote alkalinity and those below 7, acidity. A soil with a pH value of 6.0 is mildly acid; one with a pH value of 5.0, strongly acid; and one with a pH value of 4.0, very strongly acid.

[3] Statement by V. C. Beverly, agricultural county agent, Aroostook County, Maine.

Soil tests should be made to determine lime requirements, especially if lime has been used on the field in previous years. Soil tests are made by State agricultural experiment stations for a nominal fee. Recommendations are made by the stations on the basis of the soil test. In general, it is not wise to lime potato soils that have an acidity above pH 5.5.

USE OF FERTILIZERS

Importance

Fertilizing potatoes is a highly important practice in all late-crop sections under consideration in this bulletin. As many fertilizer problems require first-hand knowledge about the soil and its previous treatment, only general information is presented. To obtain specific advice on kind, amount, ratio, placement, and home mixing of fertilizer, the grower should consult his county agent and State agricultural college.

The importance of plant nutrients in potato production has been shown by numerous comparisons of fertilized and unfertilized plots (fig. 4), as well as by the experience of potato growers. When a row, or a part of a row, is planted without fertilizer the effects are generally indicated by retarded, spindly growth and reduced yield. The growers of late-crop potatoes spend close to 20 million dollars annually for commercial fertilizer. This is a heavy financial outlay, and naturally the fertilizer should be used most efficiently.

Potato plants require an ample supply of plant nutrients to insure rapid, steady growth and proper tuber development. Moreover, these requirements must be met at the beginning of growth, as any delay in applying the fertilizer much beyond planting time might

Figure 4.—Comparison of unfertilized (center) and fertilized rows (each side) of potatoes. Lighter-than-normal foliage, early blossoming, and early maturity are indications that no fertilizer was used.

easily lead to a reduced yield. While there is a supply of available nutrients naturally present in the soil it must usually be supplemented with fertilizer to obtain maximum production. Decaying organic matter and barnyard manure also furnish some nutrients, but usually at too slow a rate to be adequate for the potato crop.

Kind and Amount

The kind and amount of fertilizer required for successful potato production will depend to a considerable extent on the kind of soil and its state of fertility, on the available manure and its condition, and on the rotation practiced. It is generally conceded that fertilizer is most effective when an ample supply of moisture is present in the soil.

The most satisfactory fertilizer for the potato crop is one containing the three major plant-food constituents—nitrogen, phosphoric acid, and potash—in proper proportions. Complete fertilizer is generally used in late-crop potato sections, although sometimes nitrogen may not be considered necessary on muck and peat. In some sections where an ample supply of well-kept manure is used the only fertilizer material may be superphosphate. Although good yields may be obtained with manure reinforced with superphosphate, nevertheless it is usually conceded that a complete fertilizer gives better yields at less cost per bushel.

The nitrogen, phosphoric acid, potash ratio is important. No one ratio will fit all potato soils of the late-crop belt, but 1–2–1, 1–2–2, 1–2–3, 1–4–2, and 1–4–4 are the ones most widely recommended and used. Fertilizer analyses corresponding to these particular ratios are 5–10–5, 5–10–10, 4–8–12, 4–16–8, and 3–12–12 or 4–16–16. Double-strength fertilizers corresponding to these ratios contain twice as much nitrogen, phosphoric acid, and potash per ton. Other fertilizer analyses, such as 4–8–7, 4–8–8, 5–8–7, and 6–9–12, also are being used to a considerable extent.

The rate of fertilizer application varies from one potato-producing section to another, depending to a large extent on rainfall and soil factors. In sections of New England, notably in Aroostook County, Maine, growers customarily use a ton or more to the acre, the rate depending largely on the closeness of seed spacing and to some extent on the variety planted. Growers of certified seed are finding closer spacing an advantage, as it tends to produce tubers of more uniformly smaller size. A spacing of 8 inches between hills and 36 inches between rows means about 22,000 plants per acre, or about 50 percent more than at a 12-inch spacing. Naturally this means a greater competition for plant nutrients; hence some growers feel justified in applying 2,500 to 3,000 pounds of complete fertilizer to the acre.[4]

In New Jersey and on Long Island, N. Y., most growers in the highly commercial potato-producing districts use 1,800 to 2,000 pounds of fertilizers to the acre. Farmers in these districts having manure available may use less. In Pennsylvania, and to some extent in southern and western New York, less fertilizer is used, the rates ranging from 600 to 1,200 pounds per acre in accordance with the supply of manure.

[4] Equivalent to 1,250 to 1,500 pounds of double-strength fertilizer.

Michigan growers average about 500 pounds to the acre for the lighter soils, with higher rates for the heavier types. Minnesota and Wisconsin growers are using more complete fertilizer than in years past, the rate of application depending on soil conditions. On the lighter sandy soils in sections where moisture is apt to be lacking, 500 pounds per acre is considered the maximum. On heavier soils, where growing conditions are more favorable, the rate of application of complete fertilizer ranges from 600 to 1,000 pounds per acre.

In all late-crop States growers will do well to follow the recommendations of the county agents and extension specialists relative to fertilizer practice.

High-Analysis Fertilizers

High-analysis fertilizers have come into much wider use in recent years, particularly in sections where heavy applications of fertilizer are made. Before World War II many potato growers had adopted the use of double-strength fertilizers.[5] In Maine in 1940 more than half of the plant food used was derived from double-strength fertilizers. The movement to do away with low-analysis fertilizers, which has had the support of agricultural agencies and the fertilizer industry, is rapidly gaining ground.

Fertilizers containing less than 20 units[6] of nitrogen, phosphoric acid, and potash are not being recommended for producing the late crop. Those containing more than 20 units, such as 5–7–10, 5–8–10, 5–10–10, 5–8–12, 6–9–12, 8–16–14, 8–16–16, and 8–16–20 mixtures, are coming into wider use. Their advantage may be illustrated as follows. In some sections growers who were using a fertilizer with a 4–8–8 analysis have changed to one with a 5–10–10 analysis. Both of these have a 1–2–2 ratio, but 1,600 pounds of 5–10–10 is equivalent to 2,000 pounds of 4–8–8 in terms of plant food. A grower planting 50 acres and using 4–8–8 fertilizer at the rate of 2,000 pounds to the acre would need 50 tons, but if he were to use the 5–10–10 fertilizer he would need only 40 tons. With the 4–8–8 mixture there would be 1,000 100-pound bags to haul, store, and handle but with the 5–10–10, only 800. Growers appreciate the 20-percent reduction in weight, the smaller storage space required, the lower cost of transportation and bags, and the greater efficiency derived from labor. A 10–16–20 fertilizer applied at the rate of 1,000 pounds to the acre is equivalent to 2,000 pounds of 5–8–10 in terms of plant food; it is obvious that bags, freight, storage, and handling are cut in half by using the double-strength fertilizer. There is also much less refilling of the fertilizer hoppers involved, a time- and labor-saving proposition very much appreciated during the busy planting season. Treble-strength fertilizers also have been tried out experimentally to some extent with good results (fig. 5).

Cooperative studies in Maine, New York, and New Jersey indicate that double-strength fertilizer when properly applied is generally just as satisfactory as ordinary-strength fertilizer. Double-strength fertilizers with excellent drilling properties can be produced. This is important because any fertilizer mixture should be in good drillable condition at planting time to insure uniform distribu-

[5] Wartime restrictions greatly curtailed the production of double-strength fertilizers. However, now that the war is over such fertilizers will no doubt become increasingly available.

[6] Total percentage of nitrogen, phosphoric acid, and potash per ton. A unit is 1 percent of a ton.

Figure 5.—A Maine potato field treated with treble-strength fertilizer (18–27–18) at the rate of 679 pounds per acre. This field produced 100 barrels of potatoes per acre, identical with the yield on fields treated with 2,000 pounds of 6–9–6 fertilizer.

tion to each plant. Lumpy fertilizer generally has to be screened; screening is annoying and time-consuming.

Placement

Field studies comparing different methods of fertilizer placement have shown that the most effective method of applying fertilizer for potatoes is in a band on each side of the seed pieces, about 2 inches away from them at their level or slightly below (fig. 6). On sloping land, in order to prevent fertilizer from getting too close to the seed pieces by shifting of the planter, it is recommended that the depth of fertilizer placement be about an inch below the seed-piece level.

When applied in the row and mixed with the soil, some of the fertilizer is apt to come in contact with the seed pieces and to result in retarded germination, weak plants, and greatly reduced yields. In Maine, for example, a 4-year average yield when fertilizer was placed at the side was 43 bushels per acre higher than when the fertilizer was mixed with soil in the row; in Michigan, 26 bushels higher; and in New Jersey, 24 bushels higher. Comparisons in other States gave results of the same order. The additional yields so obtained were not from any change in the kind or quantity of fertilizer used but from a difference in the placement of the fertilizer.

Fertilizers should never come in direct contact with seed pieces or be deposited directly over them. Either position may mean a poor stand.

Avoidance of Nutrient Deficiencies

Magnesium, like nitrogen, phosphorus, and potassium, is an essential plant-food element. It is a component of chlorophyll, the green

Figure 6.—Comparison of different fertilizer placements for potatoes in Ohio. *a,* Fertilizer applied in two bands 2 inches to each side of seed pieces; yield, 211.2 bushels per acre. *b,* Fertilizer in contact with seed pieces; yield, 108.7 bushels per acre. *c,* Fertilizer in band 2 inches under seed pieces; yield, 195.9 bushels per acre. (Conducted cooperatively by the Ohio Agricultural Experiment Station and the United States Department of Agriculture.)

coloring matter of plants; if there is a lack of available magnesium in the soil the formation of chlorophyll is checked and normal growth activities are seriously disturbed. In severe cases of magnesium deficiency the entire plant is affected; the yellow-spotted leaves turn brown and frequently drop off. Fields so affected produce uniformly low yields. The symptoms of magnesium deficiency are shown in figure 7.

About 17 or 18 years ago magnesium-deficiency symptoms occurred in many potato fields along the Atlantic seaboard. Foliage of potato plants failed to develop the normal green color, at first being pale green and later changing to light yellow. The loss of green started at the tips and margins of the first leaves and progressed inward between the veins toward the centers of the leaflets. The foliage displayed a definite bulging between the veins and a characteristic thickening and brittleness.

The main factors causing the magnesium deficiency were heavy use of acid-forming fertilizers low in magnesium on potato soils already too acid, the leaching effect of prolonged rainfall before planting, and the lack of soil organic matter. Remedies included the addition of an available magnesium compound to the fertilizer, the use of potassium magnesium sulfate as a source of potash, an application of dolomitic limestone to the soil, and the use of dolomitic limestone in fertilizer.

Of the secondary elements only magnesium has been found definitely lacking in potato soils, but other deficiencies are possible. Calcium and sulfur compounds are present in all soils, and appreciable amounts are added to the soil in fertilizer, particularly those containing ordinary superphosphate and ammonium sulfate. As double-strength fertilizer contains no ordinary superphosphate, it may become necessary to add calcium and sulfur compounds to prevent possible deficiencies of these elements. A deficiency of iron is only a remote possibility in potato soils having an acid reaction, as sufficient iron occurs in the soil solution to take care of normal growth requirements. Boron, manganese, and zinc have not been found deficient for potatoes in the late-crop areas under discussion. The boron requirement of the potato is relatively low; manganese and zinc, like iron, are available in acid soils in sufficient amounts. Copper has been found deficient on certain mucks and peats, but the amount added in sprays appears sufficient to prevent a deficiency of this element in most late-crop potato soils.

VARIETIES FROM WHICH TO CHOOSE

A relatively large number of varieties of potatoes are grown in the late- or main-crop sections of the United States. These differ in their time of maturity, yield, appearance, cooking and marketing qualities, and resistance to various destructive diseases and insects. Some varieties are susceptible to all of these, whereas others are resistant to one or more. All other characteristics being equal, resistance to even one destructive disease or insect makes a variety better than a susceptible one. A variety that is good in one section may be of little value in another. The grower is warned, therefore, against buying large quantities of high-priced seed stock of a recently introduced variety or of one reported superior in other localities until he learns

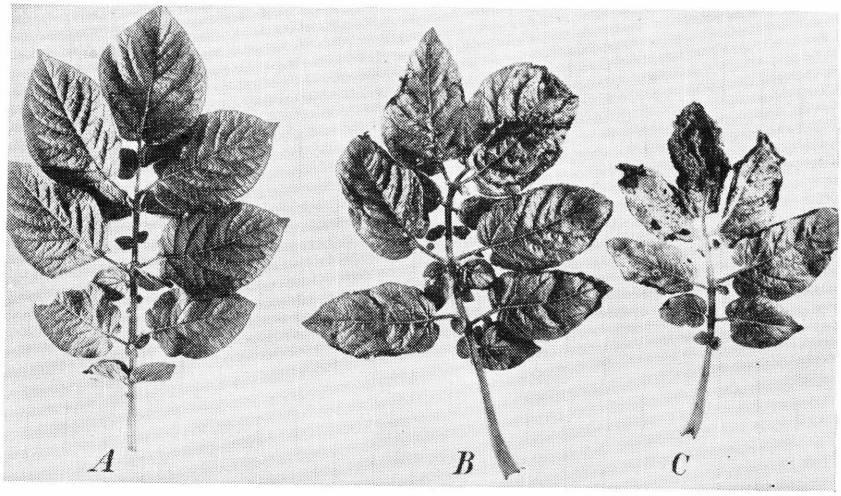

Figure 7.—Symptoms of magnesium deficiency on potato foliage: *A,* Normal leaf; *B,* leaf with intermediate symptoms (lighter-than-normal green color and preliminary break-down of tissue); *C,* leaf with advanced symptoms (dead tissue, pronounced loss of color, and brittleness).

whether it is adapted to his environmental conditions. The best procedure is for him to obtain the pertinent information from his county agent or State agricultural college or to test the variety himself on a limited scale.

OLDER VARIETIES IN COMMERCIAL PRODUCTION

For many years the principal commercial varieties of potatoes were those originated 50 to 75 years ago as a result of hybridization, as mutations or sports, or as chance seedlings. A number of these still in production in the Northeastern and North Central States are described briefly in this section for the benefit of those who wish to test or to grow them.

Early Ohio.—Early, maturing about 10 days later than Triumph. Grown commercially in Minnesota, North Dakota, Iowa, and Nebraska. Adapted to the Red River Valley gumbo soils and to the sandy-soil districts of Minnesota. Tubers medium in size, round-oblong to somewhat cylindrical (largest tubers), seed and stem ends rounded; skin smooth, pink, lighter at base than at apex; lenticels prominent; eyes numerous, moderately shallow, sometimes protuberant, pink; flesh white, sometimes with color in cortex. Flowers white. Susceptible to virus diseases and wart. Cooking quality good.

Green Mountain.—Late. Extensively grown in the Northeastern States, where it produces high yields of good quality. Being replaced in some States by certain of the newer varieties, chiefly Katahdin, Sebago, and Sequoia. Production limited to cool and reasonably moist climate and to the lighter types of soil. Tubers (fig. 8) large, short-oblong to oblong, broad, flattened, ends usually blunt; skin smooth or often netted, white; eyes medium in depth,

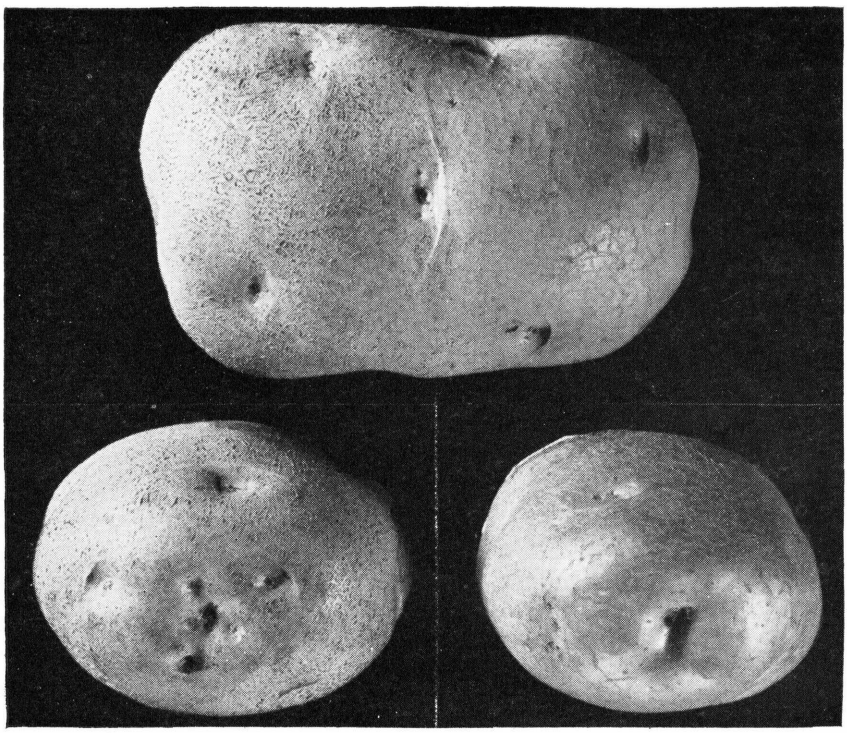

Figure 8.—Green Mountain tubers. About three-fifths natural size.

white; flesh white. Flowers white. Immune to wart but susceptible to most of the other common potato diseases. Net necrosis develops extensively in storage from current-year leaf roll infection. Cooking quality usually very good.

Irish Cobbler.—Early maturing. Of wide adaptation; grown in nearly every State. Adapted to muck and the lighter soils, preferring cool conditions and ample moisture supply. Tubers (fig. 9) large to medium in size, roundish with blunt ends, the stem end often notched rather deeply, giving a shouldered appearance to the tuber; skin smooth, creamy white; eyes shallow to rather deep, particularly in bud-eye cluster; flesh white. Flowers lilac with white tips, bleaching nearly white under prolonged, intense heat. Susceptible to most virus diseases and very susceptible to common scab; resistant to mild mosaic and immune to wart. Cooking quality usually good.

Rural New Yorker No. 2.—Late. Production confined chiefly to eight of the States that produce late potatoes, the bulk of the acreage being in New York, Pennsylvania, Wisconsin, and Minnesota. Being replaced in some districts by Katahdin, Chippewa, and Sebago. Well recommended for the heavier types of soil, doing well under adverse conditions. Tubers large, broadly oblong, flattened; skin smooth, occasionally somewhat netted, creamy white; eyes few, except for bud-eye cluster, which is frequently depressed; flesh white. Flowers purplish violet with white tips. Susceptible to virus diseases, fusarium wilt, and yellow dwarf and very susceptible to wart. Cooking quality good, but offset to some extent by blackening after cooking.

Russet Rural.—Late. Grown extensively in Michigan, Pennsylvania, Wisconsin, Minnesota, Ohio, and New York. Tubers (fig. 10) large, broadly oblong, flattened; skin somewhat netted, russet, occasional tubers only partly russet; eyes few, shallow except for bud-eye cluster, which is frequently depressed; flesh white. Flowers purplish violet with white tips. Very susceptible to wart, but somewhat resistant to common scab. Cooking quality good; keeps well in storage.

Triumph.—Early maturing. Widely adapted; grown commercially in 25 States; of greatest importance in Southern and Midwestern States. Tubers large to medium, round, thick; skin smooth, uniformly colored, red; flesh white. Flowers pink. Susceptible to most diseases, including wart. Fairly mealy when cooked.

RECENTLY INTRODUCED VARIETIES IN COMMERCIAL PRODUCTION

In recent years a number of new varieties have been originated and distributed by the national potato-breeding program [7] to growers in the districts where the late crop of potatoes is grown. These varieties are described so that readers will know the characteristics that make each suitable or unsuitable for his environment.

Chippewa.[8]—Midseason, 10 to 15 days later than Irish Cobbler. Widely distributed, reaching its greatest importance in Maine, Indiana, Michigan, Minnesota, New York, North Dakota, and Wisconsin. Doing well on peat or muck, especially adapted to such soils in Indiana and New York, where large crops of good quality are produced; but in most other sections table quality poor. Tubers (fig. 11) large, elliptical to oblong, medium in thickness; skin smooth, dark creamy buff; eyes shallow, of same color as skin; flesh white. Flowers lilac with white tips. Susceptible to wart, spindle tuber, and leaf roll, but to date no net necrosis found in tubers as a result of leaf roll infection; resistant to mild mosaic. Cooking quality fair to poor.

Earlaine.[9]—Early. Of little commercial importance, but valuable in breeding for earliness, good tuber shape, and resistance to mild mosaic. Tubers medium

[7] Organized and conducted cooperatively by the Division of Fruit and Vegetable Crops and Diseases, more than 30 State agricultural experiment stations, and the Hawaii Agricultural Experiment Station.

[8] The name of a tribe of Indians that occupied the region from Lake Huron to North Dakota.

[9] Combination of first four and last four letters of early Maine.

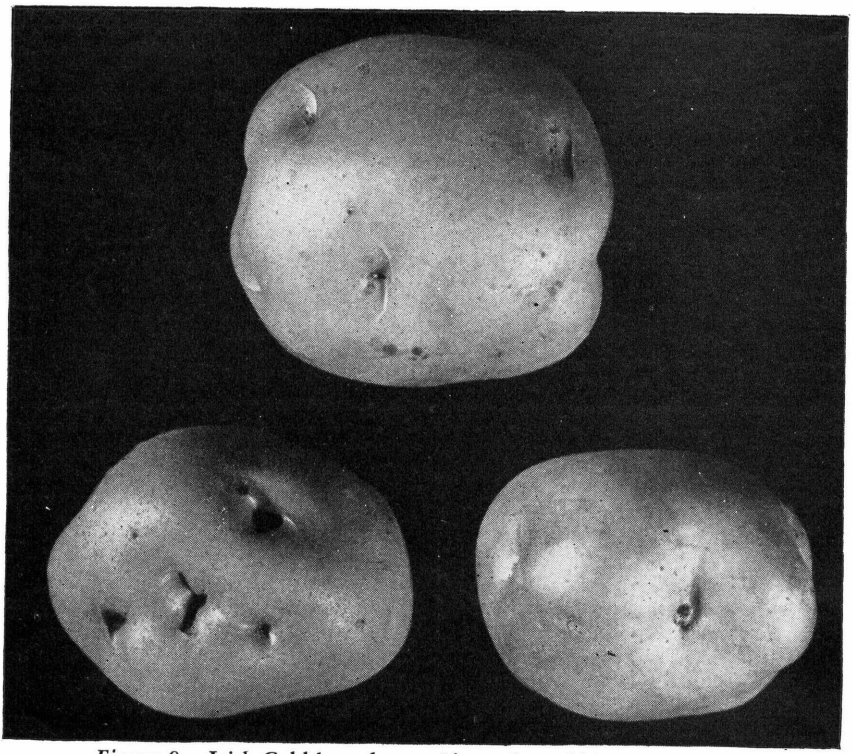

Figure 9.—Irish Cobbler tubers. About three-fifths natural size.

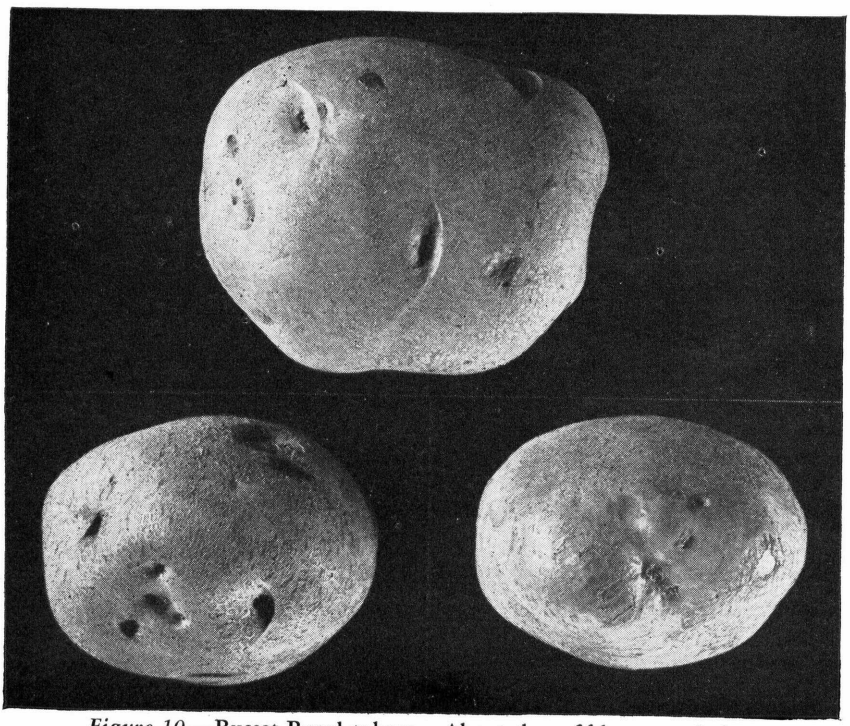

Figure 10.—Russet Rural tubers. About three-fifths natural size.

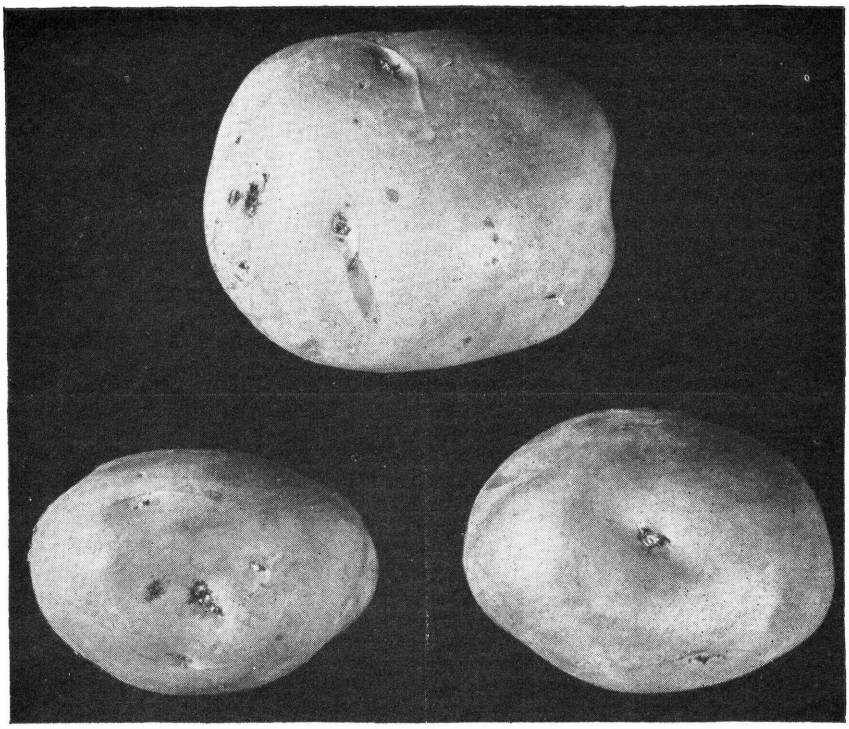

Figure 11.—Chippewa tubers. About three-fifths natural size.

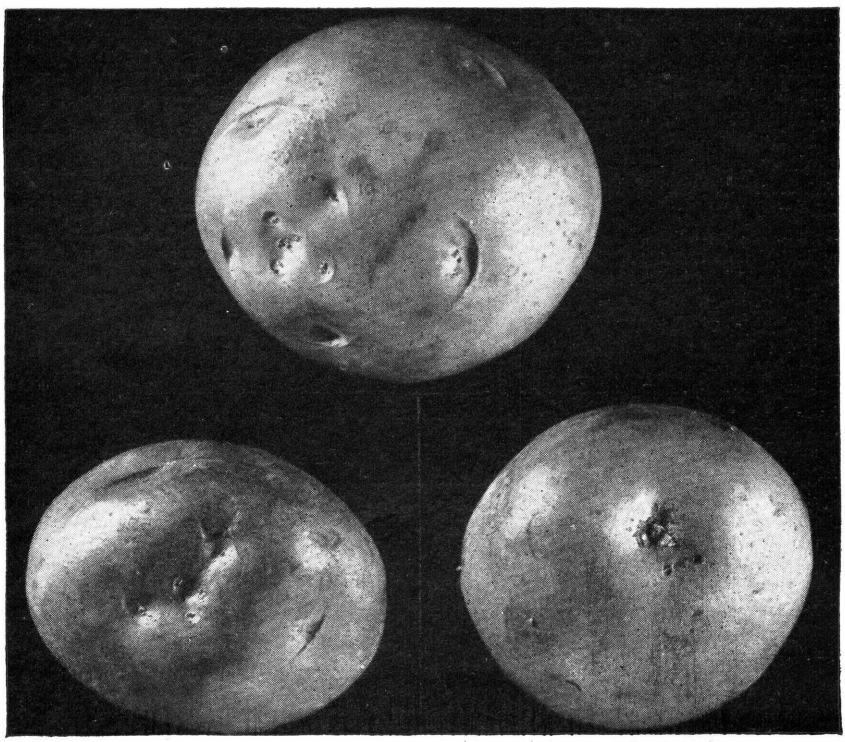

Figure 12.—Katahdin tubers. About three-fifths natural size.

in size, roundish, thick; skin slightly flaked, ivory yellow; eyes medium in depth to shallow, of same color as skin; flesh white. Flowers white. Highly resistant to mild mosaic under field conditions, but susceptible to wart. Cooking quality fair to poor.

Houma.[10]—Midseason. Finding favor in some States because of its good shape, usually good cooking quality, and high yield. Tubers large to medium in size, roundish, flattened at apex, width greater than length, medium in thickness; skin smooth or slightly flaked; eyes medium in depth, of same color as skin. Flowers white. Resistant to mild mosaic and net necrosis; very resistant to wart; also somewhat resistant to drought. Cooking quality good.

Kasota.[11]—Midseason; under Minnesota conditions maturing earlier than Chippewa and Pontiac and later than Triumph and Irish Cobbler. Adaptation not yet fully determined. Tubers broadly roundish, flattened, usually wider than long, medium thick; skin smooth, medium red; flesh white. Flowers light lavender. Cooking quality about the same as that of Triumph, although tubers slightly mealier in texture.

Katahdin.[12]—Late; maturing a little later than Green Mountain and at about the same time as Rural New Yorker No. 2. Adaptation wider than that of Chippewa. Tubers (fig. 12) large, elliptical to roundish, medium in thickness; skin smooth, dark creamy buff; eyes shallow, of same color as skin; flesh white. Flowers lilac with white tips. Resistant to mild mosaic, net necrosis, and brown rot and immune to wart; not becoming infected with leaf roll as readily as most other varieties. Cooking quality medium to good.

Menominee.[13]—Late; maturing at about the same time as Russet Rural and Sebago. Adaptation not fully determined. Tubers (fig. 13) cubical, flattened at apex, width slightly greater than length, medium thick, with tendency to be slightly rough and more irregular in shape than those of either Chippewa or Katahdin; skin slightly flaky to moderately russet if allowed to mature; eyes medium deep; flesh white. Flowers white with medium-lilac tips. Highly resistant to common scab and moderately resistant to late blight; not affected by leaf roll or mosaic in 6-year test in Michigan. Cooking quality good—about on a par with that of Russet Rural.

Mesaba.[14]—Early. Adaptation and disease resistance not widely determined; tested most extensively in Minnesota and Iowa. Tubers medium in size, short, roundish, medium in thickness; skin slightly flaked to smooth, creamy buff; eyes shallow, of same color as skin; flesh white. Flowers pale lilac. Leaves thick, rugose, a characteristic that adds to the difficulty of roguing for virus diseases; immune to wart. Market and cooking quality high.

Mohawk.[15]—Midseason to late. Tubers (fig. 14) elongated, thick, smooth, shallow-eyed, with excellent appearance. Resembles Green Mountain, one of its parents. A good set and a high percentage of No. 1 tubers usually produced. Flowers white with pink tips. Reported resistant to mild mosaic and to net necrosis due to leaf roll but in common with most varieties susceptible to leaf roll. No present evidence of resistance to common scab or late blight. Mealy when cooked; bakes well.

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[10] Tested at Houma, La.

[11] An Indian word referring to a clearing; selected because it contains the last syllables of Nebraska and Minnesota.

[12] The name of the highest and most pronounced mountain in Maine, the State in which this variety originated. The name is of Indian origin and signifies venerable mountain.

[13] Menominee is the name of an Algonquian Tribe of Indians of the central group who have lived near the Menominee River, southwest of Lake Michigan, since its discovery by the white man early in the seventeenth century.

[14] Presumably for the Mesaba range of hills in northeastern Minnesota.

[15] Tested in the Mohawk Valley, N. Y.

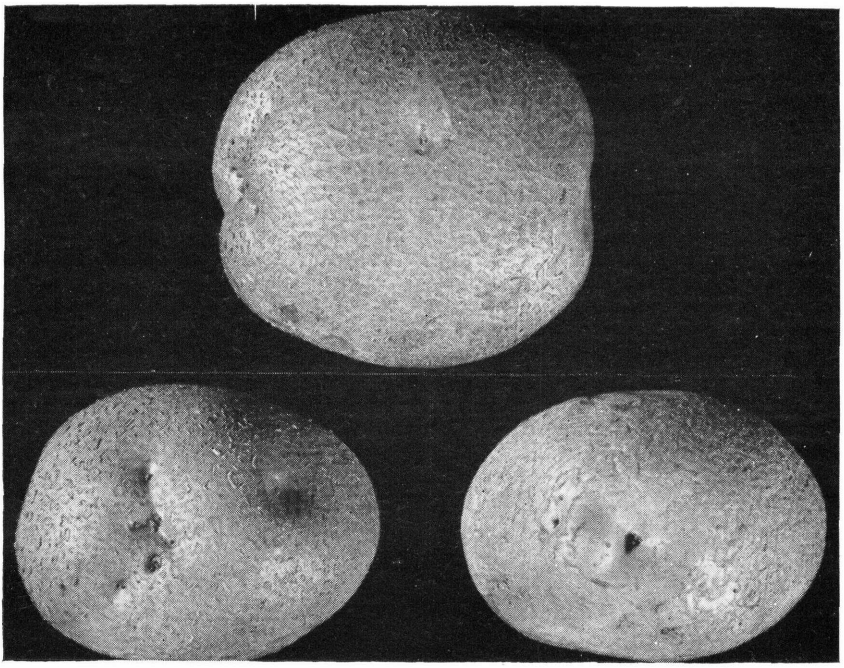

Figure 13.—Menominee tubers. About three-fifths natural size.

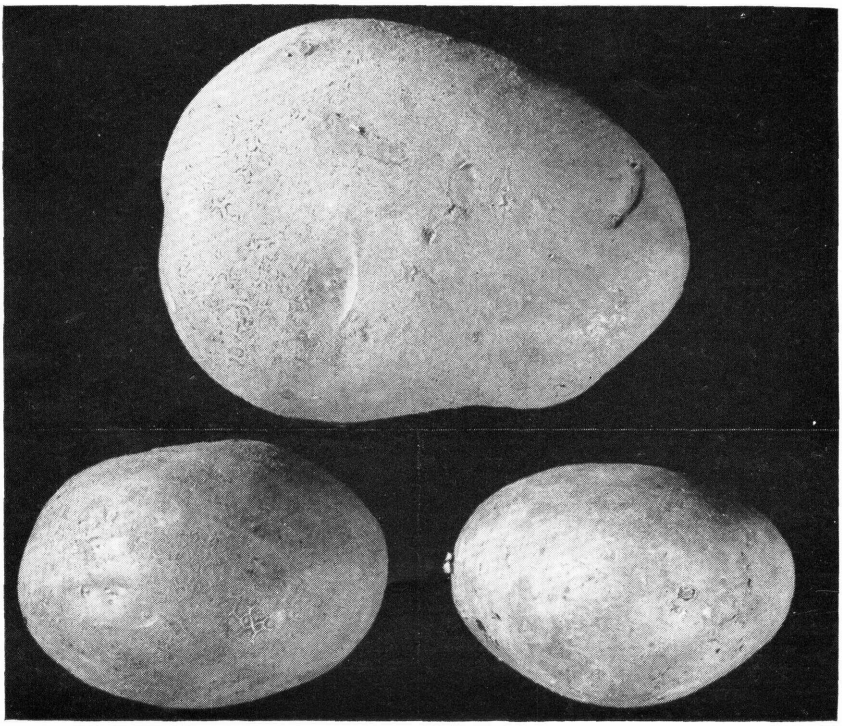

Figure 14.—Mohawk tubers. About three-fifths natural size.

Pawnee.[16]—Medium early. Adaptation not widely determined; performance good in Maine and Minnesota. Tubers smooth, short elliptical to roundish, medium thick; skin smooth, self-colored, varying from cream to dark-cream buff; flesh white. Flowers purplish violet, somewhat similar to those of Rural New Yorker No. 2. Reported fairly resistant to common scab. Good keeping and cooking qualities.

Pontiac.[17]—Late. A high-yielding variety of value in sections where red varieties are in demand; especially adapted to muck soils in Michigan and in recent tests showing promise in parts of Florida, Wisconsin, Minnesota, and North Dakota. Tubers (fig. 15) large, oblong to round, blunt at ends; skin smooth or sometimes netted, uniformly colored, red; eyes medium in depth, red; flesh white. Flowers light reddish purple with tips nearly white. Not markedly resistant to common scab or virus diseases; in some trials in Michigan and Ohio more drought-resistant and free from hollow heart and misshapen tubers than other varieties. Cooking quality good.

Red Warba.—Very early. Sport of Warba, with same general characteristics except tuber color. Tubers (fig. 16) medium in size, short, round; skin smooth, red, uniformly colored except for an occasional tuber with small white areas; eyes mostly deep, red; flesh white. Flowers pink. Susceptible to virus diseases. Cooking quality good.

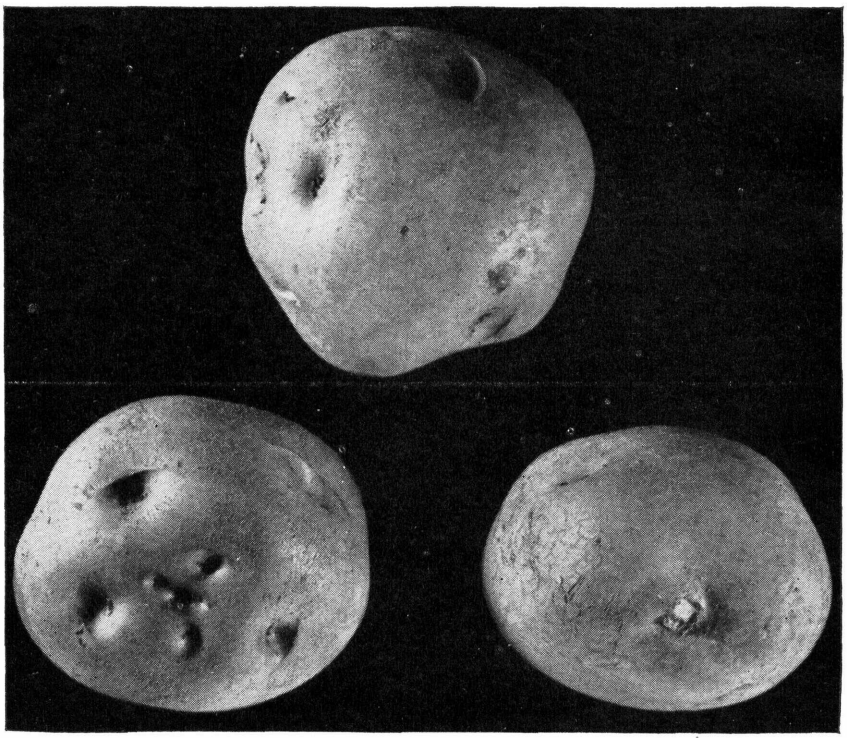

Figure 15.—Pontiac tubers. About three-fifths natural size.

[16] The name of scenic buttes in Weld County, Colo., where this variety originated. Pawnee is also the name of a tribe of American Indians that formerly roamed the Plains region from Nebraska to Texas.

[17] For the famous chief of the Ottawa Indian Tribe that inhabited the Great Lakes region in colonial times.

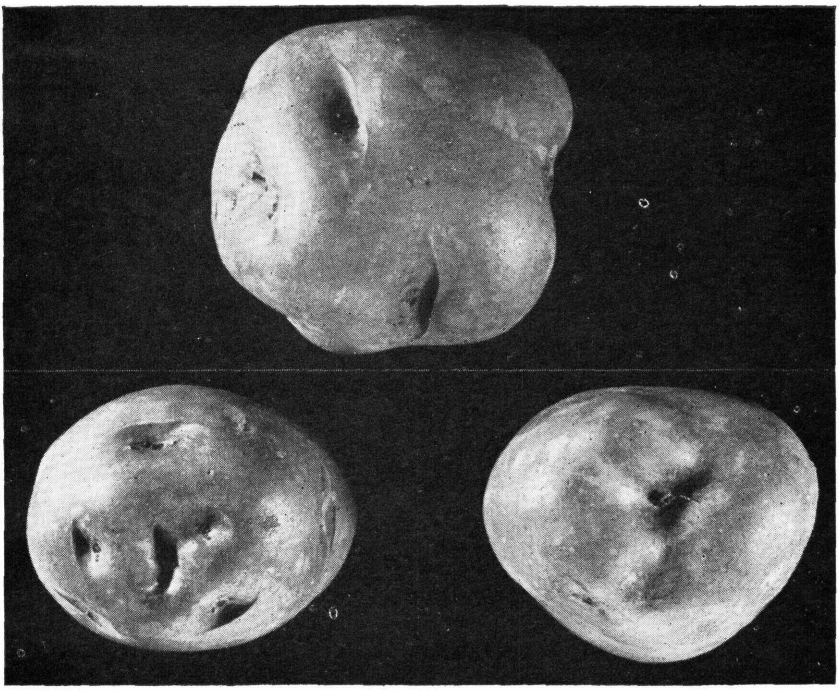

Figure 16.—Red Warba tubers. About three-fifths natural size.

Sebago.[18]—Late. Firmly established commercially and increasing in production in the Northeastern and Western States. High yielding. Tubers (fig. 17) large, elliptical to round-elliptical, medium in thickness; skin smooth, ivory yellow; eyes shallow, of same color as skin; flesh white. Flowers lilac with tips slightly lighter in color. Resistant to mild mosaic and net necrosis; its vines and tubers moderately resistant to late blight; resistant to brown rot in Florida; resistant to yellow dwarf, indicated by tests in New York and Wisconsin; susceptible to wart. Cooking quality variable but usually good if tubers are allowed to fully mature before being dug.

Sequoia.[19]—Late. Adaptation wide. High yielding. Tubers large, roundish, flattened; skin smooth, white; eyes shallow, bud-eye cluster frequently depressed, more pronounced in large tubers, white; flesh white. Flowers white. Somewhat resistant to mild mosaic and late blight and immune to wart. Especially valuable for its resistance to leafhopper and flea beetle injury in areas where these insects are prevalent. Cooking quality generally medium to good.

Warba.[20]—Very early. A high-yielding variety, widely distributed but grown as a commercial crop only in the Midwestern States. Tubers medium in size, short, round; skin creamy white, frequently with reddish areas around eyes; eyes mostly deep, red; flesh white. Discriminated against in some markets because of deep eyes and unattractive color. Flowers pink, sparse in number. Susceptible to mosaic and wart. Cooking quality good.

[18] First grown near Sebago Lake, Maine.

[19] Sequoyah, or Sikwayi, was a famous Cherokee Indian chief born in North Carolina.

[20] An Indian word of the Ojibway Tribe, indicating earliness.

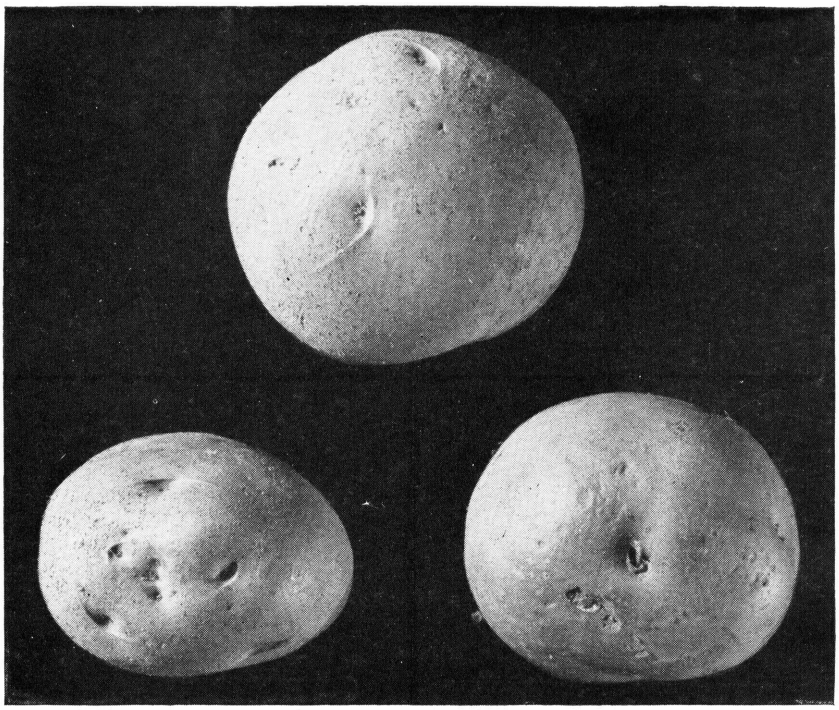

Figure 17.—Sebago tubers. About three-fifths natural size.

IMPORTANCE OF GOOD SEED STOCK

The potato industry consists of two specialized branches, namely, the production of seed potatoes and the production of table stock. The seed-potato areas are generally restricted to those localities where temperature, rainfall, and soil conditions are suitable for the growing of potatoes of excellent quality free from disease. Many potato diseases are carried over in the tubers, which will produce diseased plants. When potatoes are grown for seed, diseased plants have to be rogued so as to prevent spread of diseases.

The production of table stock is not so highly specialized. The grower plants certified seed, treats the tubers for the control of common scab or rhizoctonia canker, if necessary, and sprays against flea beetles, leafhoppers, and aphids. In contrast with the practices of the certified-seed producer, he makes no special effort to eliminate in the field plants affected with virus, wilt, or other diseases that do not directly impair the cooking quality of potatoes.

In 1944 the crop of certified seed potatoes, the largest on record up to 1945, when 33,005,803 bushels was produced, was 32,497,139 bushels, as compared with 29,044,068 bushels in 1943, the previous high record, and 18,731,000 bushels in 1940.[21] The average production for the 5-year period (1940–44) was 23,636,320 bushels. Certifying agencies of 26 States reported production of certified seed potatoes in 1944.

[21] Crop Reporting Board, Bureau of Agricultural Economics, U. S. Department of Agriculture.

Although only 12 States in the Northeastern and North Central States reported such production, it is noteworthy that they produced 26,627,206 bushels of certified seed; also, 3 of these—Maine, North Dakota, and Minnesota—produced 23,174,551 bushels, about 72 percent of the total certified-seed production of the United States. Maine produced 46 percent of the total for the United States; North Dakota, 14 percent; and Minnesota, 12 percent.

Ten varieties accounted for about 95 percent of the total production of certified seed potatoes in 1944. These were Irish Cobbler, 25.35 percent; Triumph, 17.15; Katahdin, 13.7; Green Mountain, 13.18; Chippewa, 5.65; Sebago, 5.57; Russet Burbank, 5.51; White Rose, 4.75; Red McClure, 2.17; and Russet Rural, 1.64. In 1944 the varieties Irish Cobbler, Triumph, Katahdin, and Green Mountain maintained the same order of importance as in 1943. Fifth place in 1944, however, went to Chippewa instead of to Sebago. In 1944 the average yield per acre of certified seed for the United States was 206 bushels, but that in 1943 was 231 bushels, an all-time high.

The shift of potato production to places such as Maine and Idaho, where production per acre is much higher than that in the older potato-producing States, has been an important factor in increased yields per acre for the United States as a whole. An increasing use of certified seed has contributed to such greater yields, but other factors such as a better knowledge and placement of fertilizers and heavier use of them, introduction of disease-resistant and high-yielding varieties, more thorough spraying, and better all-round cultural care have also been important.

In every State where seed potatoes are grown extensively, certification agencies have been established. If a field registered for certification passes inspection, the grower is furnished with tags that declare his potatoes suitable for seed purposes. The certification requirements are now fairly uniform in the different States. In general, three inspections are made: The first as early as possible to identify diseases; the second, between the time of flowering and the time just before the plants mature; and the third, after the crop is graded. Some States have an extra inspection to detect ring rot (bacterial ring rot) either in the field at harvesttime or in the bin after the potatoes are stored.

Certified seed costs more than the noncertified, but the extra cost is small considering the increased yields which may be expected from the use of good seed. Even the small grower appreciates that the seed stock he plants must be reasonably free from virus and fungus diseases to enable him to harvest a maximum crop.

TREATMENT OF SEED POTATOES WITH CHEMICALS

The disinfection of seed potatoes prior to planting has been regarded in many late-crop areas as one of the necessary operations in potato production. The purpose of treating with various chemicals potato tubers intended for planting is to destroy the skin-borne organisms which cause such diseases as rhizoctonia canker and common scab. This is particularly true when new land is being brought under cultivation or when land long cultivated is not seriously infested with such organisms. It is obvious, for example, that the planting of untreated scabby tubers in new land would be inviting not only the production

of scabby tubers but the introduction of the scab organism into the soil as well. The same also is true for *Rhizoctonia*. The value of seed treatment may be questioned, however, where soils are already heavily infested with the common scab organism or with *Rhizoctonia*. Where heavy scab infestation prevails, the grower would do well to consider whether it pays to try to grow potatoes. In mild cases of infestation, a combination of soil treatment with some acidifying material such as sulfur and the use of an acid-forming fertilizer are indicated. In any case a suitable rotation should be practiced.

Virus diseases and other diseases within the tuber are not affected by seed treatment. The fact that soils vary markedly from area to area in texture and structure, in cropping systems, in fertilizing treatment, in reaction, and in other factors makes it desirable for the grower to seek the advice of his extension service or agricultural college on the questions involved in the treatment of seed potatoes. The effectiveness of a treatment depends on how carefully the operator follows instructions for the disinfectant used and on the maintenance of the strength of the solution if the mercuric chloride treatment is used.

MERCURIC CHLORIDE

The effectiveness of mercuric chloride, or corrosive sublimate, as a disinfectant for potatoes has been known for a long time. The recommended strength for treating potatoes is 1 part of mercuric chloride in 1,000 parts of water (4 ounces in 30 gallons of water). Whole potatoes are treated for 30 minutes to 2 hours. Mercuric chloride goes into solution very slowly in cold water; so it should be dissolved in 2 or 3 quarts of warm water. The solution should be prepared and used in wooden, enamel, or concrete containers (fig. 18). As it decreases in strength with use, a correction should be made after each

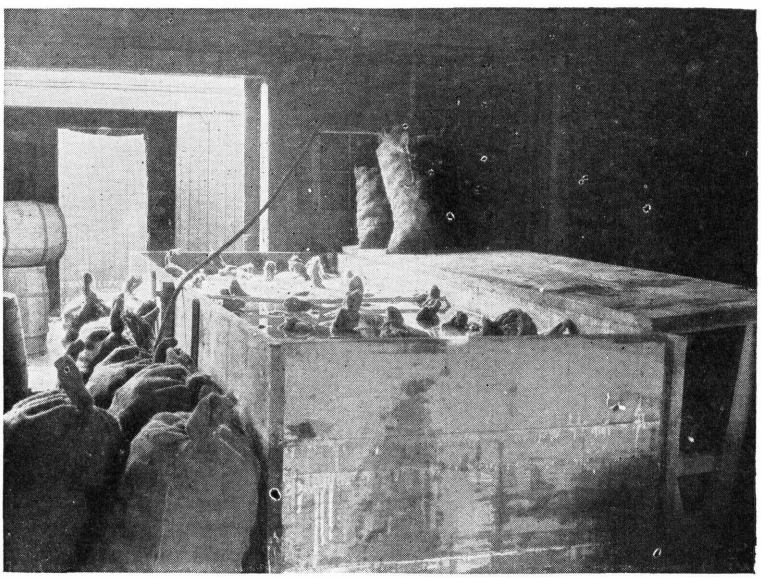

Figure 18.—Large tank commonly used for treatment of seed potatoes with mercuric chloride (corrosive sublimate).

treatment. One-half ounce of the chemical should be added to the solution for every 4 or 5 bushels of potatoes treated 2 hours, or for the same quantity of potatoes treated 1½ hours three-eighths ounce should be added. Add enough water to bring the solution up to its original volume. Make a fresh solution after treating four lots of tubers. When potatoes are contaminated with soil or carry the sclerotia of *Rhizoctonia* the solution is more effective if the potatoes are kept wet for 20 to 24 hours before treatment. Do not store wet. Recent evidence indicates that the tubers of some of the recently introduced shallow-eyed varieties, such as Katahdin, Chippewa, Sebago, and Earlaine, may be injured by this and other mercury treatments.

Mercuric chloride is a deadly poison, and great care must be taken in mixing and handling the solution to prevent any contact with the mouth, eyes, or nostrils. Rubber gloves should be worn to protect the hands and a rubber apron to protect the clothing. Unused solutions should be buried in the ground at least 1 foot deep. All vessels must be thoroughly cleaned before they are used again, and all clothing should be thoroughly cleaned. Any surplus chemical should be plainly labeled and stored out of the reach of children and animals. Sacks used for holding potatoes during treatment should be allowed to drain freely into a proper receptacle, and the drippings, if not usable again, should be buried in the ground at least 1 foot deep. Treated seed potatoes should be stored so there is no possibility of livestock eating them and segregated so that they will not be mixed with potatoes intended for human consumption.

ACID-MERCURY DIP

The acid-mercury dip method is a short-time treatment, which reduces the time factor of the mercuric chloride method. It is considered to be the most effective control for surface-borne *Rhizoctonia*. The solution is made by dissolving 6 ounces of mercuric chloride in 1 quart of commercial hydrochloric (muriatic) acid and then adding 25 gallons of water in a wooden container and stirring. Do not put the solution in a metal container, as it causes corrosion.

The strong hydrochloric acid is very caustic and should be handled very carefully.

Treat only whole tubers by placing them in either a wire basket coated with asphalt paint or wooden crates and immersing them in the treating solution for 5 minutes. The tubers should be removed and dried quickly by being spread in a clean, shaded, thoroughly ventilated place. If the tubers are not dried immediately after treatment, the eyes and skin are apt to be injured seriously. After being dried, the tubers are ready to be cut and planted. From 20 to 30 bushels of tubers can be treated before a new solution is necessary. The grower should be cautioned against subjecting certain varieties—Chippewa, Katahdin, Sebago, and Earlaine—to the acid-mercury dip if hydrochloric acid is used. Any variety is injured if it has sprouted.

In working with acid-mercury dip, use the precautions suggested for mercuric chloride (above).

Studies made by E. R. Tobey, B. E. Plummer, and Reiner Bonde, of the Maine Agricultural Experiment Station, show that acetic acid is satisfactory in the acid-mercury dip for retaining the mercury in

solution. Further, they found that distilled vinegar is satisfactory as a substitute for the more-likely-to-injure hydrochloric acid. They suggest further that treating potatoes may not be justified if the seed stock is relatively free of *Rhizoctonia.*

ORGANIC MERCURY COMPOUNDS

Organic mercury compounds are used as instantaneous dips as recommended by the manufacturer. These materials are poisonous but not corrosive and can be used in metal containers. Cut seed may be treated with them. After treatment both whole tubers and cut seed pieces should be thoroughly dried or planted immediately.

The same precautions should be exercised with organic mercury compounds as with mercuric chloride (p. 25).

YELLOW OXIDE OF MERCURY

Yellow oxide of mercury has been used for treating potatoes for several years, especially in New York. It is considered one of the best materials for an instantaneous dip, but it is not recommended for treating cut seed. It is as effective as mercuric chloride in the control of rhizoctonia canker. The best results are obtained if the tubers are planted within a few days after they are treated. If they are held more than 10 days before being planted, retarded vine growth and reduced yields will result. This treatment is not recommended in areas where the soil is alkaline enough to favor the development of common scab.

Yellow oxide of mercury is very poisonous, and the same precautions are recommended as for mercuric chloride (p. 25).

One pound of yellow oxide of mercury (technical grade) is added to 30 gallons of water in a wooden or metal container covered with a good coat of asphalt paint. The mixture should be stirred thoroughly with a wooden paddle until all the oxide is in suspension. A galvanized wire basket coated with asphalt paint will be found most useful in dipping the potatoes in the solution. The basket of potatoes should be immersed several times in the solution, being rotated at the same time to insure that all surfaces of the tubers are wet and to help keep the solution well stirred. The treated potatoes are removed from the solution, drained, and emptied into a crate or open container to dry. Several baskets should be available so that the dipping process can continue while the treated tubers are draining. It may be necessary to stir the solution at frequent intervals because the chemical must be in suspension to be effective. Because the mixture does not lose strength, it can be used as long as there is any solution left; 15 gallons will usually treat 100 or more bushels of potatoes. Normally the cost of the chemical is less than 2 cents for each bushel of potatoes treated.

COLD FORMALDEHYDE

Formaldehyde solution is prepared by adding 1 pint of commercial formalin to 30 gallons of water. It may be used for the control of common scab by soaking the uncut tubers in the solution for 2 hours. It is not effective in controlling rhizoctonia canker.

Formaldehyde solution is irritating to the skin when cold and will give off vapors irritating to the eyes and respiratory tract

when heated. Rubber gloves fitting tightly at the wrist should be worn to prevent harm to the hands. If large quantities of seed are to be treated, a rubber or oilcloth apron should also be worn to protect the clothing. Surplus solution should be safely disposed of. Vessels and clothing should be thoroughly cleaned. If this operation is carried on in a building, a gas mask equipped with a suitable canister should be worn by each one in the room.

HOT FORMALDEHYDE

The hot-formaldehyde method has become very popular in some sections of the country where community or potato associations have equipment for handling large quantities of potatoes. Where such practice prevails, the potatoes are usually treated in sacks and allowed to dry in them. Small units of 1-bushel capacity are available (fig. 19). The solution is made by mixing 2 pints of formalin in 30 gallons

Figure 19.—Small, hot-formaldehyde seed-treatment outfit suitable for use on the farm.

of water heated to a temperature of 124° to 126° F. and held within these limits by steam or by means of a fire maintained beneath the tank. The tubers are then dipped for 4 minutes. A false floor in the tank is necessary to keep the tubers at the bottom from becoming overheated. The solution should not be warmer than 126°, because above this temperature injury to the sprouting potatoes results; nor should it be cooler than 124°, as it would then not control common scab or rhizoctonia canker if the tubers are dipped for only 4 minutes. To allow for condensation of water when live steam is used for heating, 0.9 pint of formalin should be added after every 50 bushels of tubers is treated. The solution does not lose its strength on standing if it is well covered, and it may be kept safely for a few days or weeks. The efficiency of

this method is increased by covering the tubers with canvas or burlap for an hour after treatment.

A gas mask should be worn by all persons working with hot formaldehyde solution, both inside and outside buildings. Other precautions should be taken as indicated for the cold-formaldehyde treatment (p. 26).

CUTTING SEED POTATOES AND HEALING SEED PIECES

Most seed potatoes are cut by hand rather than with mechanical seed cutters (fig. 20) but the continued improvement of these seed-cutting devices is increasing their use in spite of the fact that the work they do is not so satisfactory as that done by hand. No mechanical seed-potato cutter yet devised is able to distinguish weak eyes, strong eyes, and no eyes at all. The mechanical seed cutter works satisfactorily when the tubers have been graded to a uniform size. The tendency among the potato growers today is to demand seed tubers of a more uniform size. Varieties such as Katahdin and Chippewa have few eyes on the basal half of the tuber, and when large tubers are used considerable waste results. Blocky seed pieces are desirable, as they can be handled to better advantage in the planter and are less liable to dry out or decay in the ground if weather conditions are unfavorable. The seed piece, in general, should weigh 1½ to 2 ounces and should have from one to three eyes. The Katahdin variety invariably sets a small number of tubers per plant, and therefore each seed piece should have two or more eyes or the spacing in the row should be reduced.

Figure 20.—Machine for cutting seed potatoes, Aroostook County, Maine. (By courtesy of Bangor Daily News.)

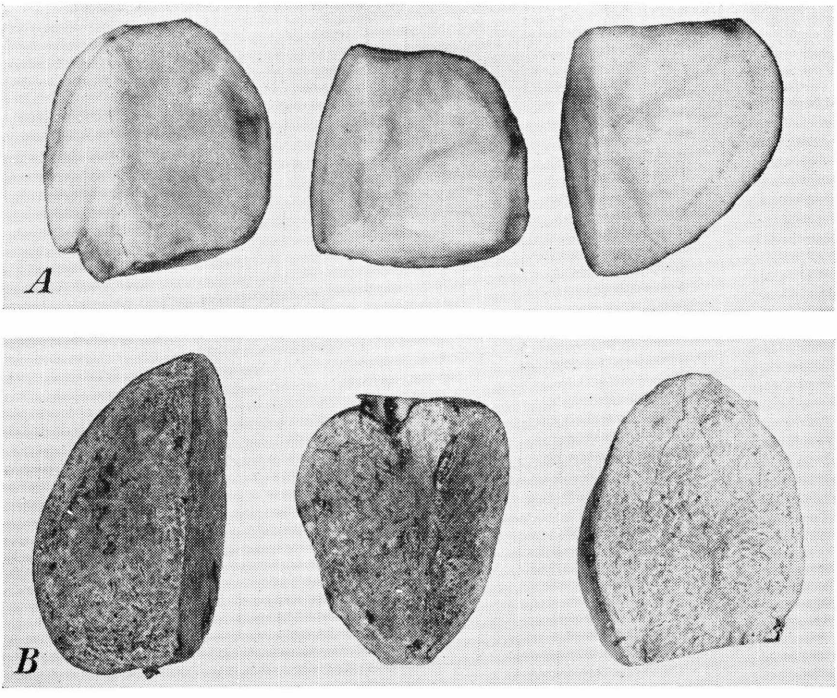

Figure 21.—Comparison of (*A*) freshly cut and (*B*) suberized, or corked-over, seed pieces. Suberization protects seed pieces from the attack of decay organisms, from drying out, from heating, and from attack by the seed-corn maggot.

The general practice among potato growers is to cut seed about the time it is needed for planting, usually having not more than a 2-day supply cut in advance. Some growers who have large acreages and are limited in time and labor during the potato-planting season have found it more economical, as well as more convenient, to cut their seed potatoes in advance of the time for planting. When seed is cut for 10 days or more, proper care should be taken to heal, or suberize,[22] the cut surfaces of the seed pieces. Seed should be planted within 30 days of cutting.

Properly healed, or suberized, seed has several advantages over freshly cut seed. It can be cut before the rush of spring planting begins; it is less likely to shrivel if the soil is too dry at planting time or to rot if it is too wet after planting; and there is no danger of heating, which often happens in the case of freshly cut seed stored in barrels or bins. Many a poor stand has been attributed to seed of poor quality when it was the direct result of improper handling.

Suberization is best accomplished by holding the cut seed at a temperature of approximately 60° F. and a humidity of about 85 percent for a week or 10 days (fig. 21). The average potato grower can maintain these conditions by keeping a fire in the workroom where the seed is cut and by having a kettle of water boiling on the stove. Slatted crates are the best type of receptacle in which to suberize cut seed;

[22] LOMBARD, P. M. SUBERIZATION OF POTATO SETS IN ITS RELATION TO STAND AND YIELD. Amer. Potato Jour. 14: 311–318. 1937.

suberizing is usually good at the temperature recommended if the crates of seed are covered with damp sacks. After the seed is thoroughly suberized, it can be stored in the potato house for at least 3 weeks, but it is not advisable to use seed that has been cut more than 30 days.

PLANTING

USE OF PLANTERS

The use of machine planters, either horse- or tractor-drawn, is general in the commercial areas (fig. 22). Hand planting is limited to gardens or tuber-unit seed plots of the commercial seed grower. The machine planters are of two general types, the picker and the assisted-feed. Two-, three-, and four-row planters of both types are now on the market and in general use in some localities. Three- and four-row planters have met with favor only in those areas where the land is comparatively level and free from rocks.

The single-row picker-type planter, which is operated by but one man, is still the favorite machine for the potato growers with 50 acres or less and with only horsepower available. This type of planter is designed with eight arms on the picker wheel and two slender, sharp, steel prongs in each arm that pick up the seed pieces as the prongs pass through a compartment containing the seed. The picker arms are operated automatically by a cam, allowing the seed piece to fall into the seed tube. Large and small picks are used, and their location on the picker arm and their size depend on the size of seed used. This machine differs from the old-style picker-planter, which picked up the seed pieces with forks attached to the revolving disk. The seed pieces were stripped off the forks as they passed between two fingerlike attachments.

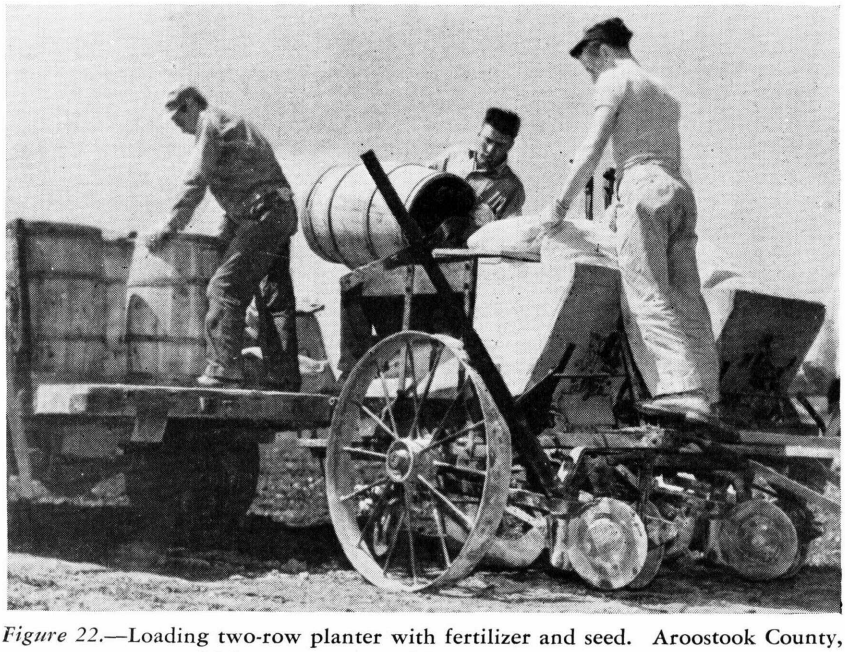

Figure 22.—Loading two-row planter with fertilizer and seed. Aroostook County, Maine. (Courtesy of Bangor Daily News.)

The assisted-feed type of planter requires the assistance of another man in the rear to see that each pocket has one seed piece in the revolving, horizontal disk which discharges the seed piece from each pocket as it passes over the dropping tube. The revolving disk is fed from the seed hopper by a revolving cogged wheel. A much larger acreage can be planted in a day with the one-row picker-type planter than with the assisted-feed type, but usually the latter type insures a better stand of potatoes. The picker type of machine planting two or more rows requires a man in the rear to check on the seed, fertilizer, and performance of the pickers.

TIME OF PLANTING

The time of planting depends upon the prevailing climatic conditions. In the Northern States the season is relatively short, and, in general, potatoes should be planted as soon as the soil can be fitted. In Aroostook County, Maine, the entire growing season is required to mature a crop of potatoes.

The critical period in the life of the potato plant occurs when it is developing its tubers, and it is essential that the climatic conditions should be as favorable as possible at this time. This period varies from location to location in accordance with the latitude and to some extent with the time of planting. In Aroostook County, Maine, in the northern section of New York, and in Michigan, Minnesota, and Wisconsin, July and August would generally cover the critical period; in New Jersey, Pennsylvania, and lower New York and on Long Island, N. Y., the critical period would be in June and July. It is during such periods that irrigation is often needed if drought prevails, as the yield is very materially reduced if a protracted spell of heat and drought occurs. If the weather is cool, the moisture is adequate, and proper disease control is used, a good yield is practically assured, provided the plants have been given proper cultural attention. In sections where the season is longer than is necessary to mature a crop, the problem is to select a planting date which will provide the most favorable climatic conditions during the period of tuber development.

RATE OF PLANTING

The spacing within the row and the distance between rows are determined in some localities by the natural fertility of the soil, its moisture-holding capacity, and the supply of available plant food that is to be applied to the crop. In the Northeastern States in the best potato soils the rows are sometimes spaced as close as 30 inches, although the average has been about 34. There has been a tendency in recent years to increase the spacing to 36 inches because of the use of motorized equipment.

Within the row the spacing averages about 12 inches, and the tendency is to narrow the distance to 10 or even 8 inches when such varieties as Sequoia and Katahdin are planted. These varieties set a small number of tubers, and closer spacing is necessary to prevent the development of a high percentage of oversize tubers. In Aroostook County, Maine, the combination of good seed, good cultural practices, and heavy fertilization produces a large percentage of oversize tubers, unless the spacing within the row is reduced below 12 inches. Close spacing in the row tends to reduce losses from hollow heart and oversize tubers and to increase the number of marketable tubers.

The quantity of seed to plant per acre depends not only on the spacing but also on the size of the seed pieces. Table 2 shows the number of seed pieces required for an acre when planted at different distances. An examination of the table shows that the closest spacing, 30 by 8 inches, would require 26,136 seed pieces to the acre, as compared with 14,520 for a spacing of 36 by 12 inches.

The general practice in the North is to use large seed pieces. On land well supplied with organic matter and available plant food and moisture, the use of large seed pieces or whole tubers from 1 to 2 ounces in weight will usually prove a profitable investment. The larger the seed pieces the more seed required per acre. Table 3 was prepared to afford a ready reference to the actual quantity of seed potatoes required to plant an acre with seed pieces of definite weights at a given distance apart.

As soil and weather conditions approach the optimum, it is usually the practice to increase the size of the seed piece and to use closer spacing. In general, the early-maturing varieties may be planted more closely than late-maturing sorts.

DEPTH OF PLANTING

No single depth of planting will give equally good results under all conditions. The determining factors are the character of soil, the season of planting, the cultural practice, and the climatic conditions that are likely to prevail during the growing season. Tuber-bearing stolons develop at the nodes on the stalk below the soil surface and above the seed piece. If the seed pieces are planted shallow it is necessary to ridge the row after or during the early cultivations so that the plants can form stolons at some distance below the surface. On good soil and where ridging is practiced, the custom is to plant the seed pieces 2 or 3 inches deep. The building up of the row is begun at the first cultivation, which usually occurs just before the plants break the ground, and is continued at each succeeding cultivation.

It is believed that good-quality potatoes develop under a fairly uniform temperature of 65° to 75° F. Tubers developing at a depth of 2½ to 5 inches are usually subject to these conditions. Great fluctuations in temperature are detrimental to the best development. Seed pieces planted too shallow are subject to these fluctuations. If they are planted too deep, the tubers on the first nodes are undersize and of poor quality. The depth of the very early planting can be less than that of the late planting, because the ground is colder and the crop is less likely to suffer from temperature and moisture fluctuations. In fields where rhizoctonia canker is known to occur, the seed pieces should be planted shallow to insure quick emergence of the sprouts above ground and thus free the plant from too early attack by the causal fungus (*Rhizoctonia solani* Kuehn). After the plants are 6 to 8 inches tall the soil can gradually be built up around them. For level culture, the seed should be planted 3 to 4 inches below the field level with a covering of not more than 2 inches of soil over the seed piece. This is easily done by dropping the opening disks and the planter shoe and raising and adjusting the covering disks so that a little soil falls to the center, leaving a depression but throwing sufficient soil over the seed to cover it adequately.

TABLE 2.—*Seed pieces required to plant an acre of potatoes at different spacings*

Distance between rows	Pieces required for stated spacing distances within rows					
	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
30 inches	26, 136	20, 909	17, 424	14, 935	13, 068	11, 616
32 inches	24, 502	19, 602	16, 335	14, 001	12, 251	10, 890
34 inches	23, 061	18, 449	15, 374	13, 178	11, 531	10, 249
36 inches	21, 780	17, 424	14, 520	12, 446	10, 890	9, 680

TABLE 3.—*Seed potatoes required to plant an acre at different spacings with seed pieces of various weights*

Spacing of rows and seed pieces	Quantity required with seed pieces of the average weight indicated				
	1 ounce	1¼ ounces	1½ ounces	1¾ ounces	2 ounces
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Rows 30 inches apart:					
8-inch spacing	27. 2	34. 0	40. 8	47. 6	54. 4
10-inch spacing	21. 8	27. 2	32. 6	38. 0	43. 5
12-inch spacing	18. 1	22. 7	27. 2	31. 7	36. 3
14-inch spacing	15. 6	19. 5	23. 4	27. 3	31. 2
16-inch spacing	13. 6	17. 0	20. 4	23. 8	27. 2
18-inch spacing	12. 1	15. 2	18. 2	21. 2	24. 2
Rows 32 inches apart:					
8-inch spacing	25. 5	31. 1	38. 2	44. 6	51. 0
10-inch spacing	20. 4	25. 5	30. 6	35. 7	40. 8
12-inch spacing	17. 1	21. 3	25. 6	29. 9	34. 1
14-inch spacing	14. 5	18. 2	21. 8	25. 4	29. 1
16-inch spacing	12. 8	16. 0	19. 2	22. 4	25. 6
18-inch spacing	11. 3	14. 2	17. 0	19. 8	22. 7
Rows 34 inches apart:					
8-inch spacing	24. 0	30. 0	36. 0	42. 0	48. 0
10-inch spacing	19. 2	24. 0	28. 8	33. 6	38. 4
12-inch spacing	16. 0	20. 0	24. 0	28. 0	32. 0
14-inch spacing	13. 7	17. 2	20. 6	24. 0	27. 5
16-inch spacing	12. 0	15. 0	18. 0	21. 0	24. 0
18-inch spacing	10. 6	13. 3	16. 0	18. 7	21. 3
Rows 36 inches apart:					
8-inch spacing	22. 7	28. 3	34. 0	39. 7	45. 3
10-inch spacing	18. 1	22. 7	27. 2	31. 7	36. 3
12-inch spacing	15. 1	18. 9	22. 6	26. 4	30. 1
14-inch spacing	12. 9	16. 2	19. 4	22. 6	25. 9
16-inch spacing	11. 3	14. 2	17. 0	19. 8	22. 7
18-inch spacing	10. 1	12. 7	15. 4	17. 7	20. 3

CULTIVATION

The objectives in cultivation are to destroy weeds, aerate the soil, encourage root growth, and supply soil covering for the developing tubers. Cultivation of potatoes starts when the soil is being prepared for planting, for thorough preparation before planting is important. One harrowing before the potatoes come up is worth two afterward. A good practice followed by some growers is to roll down the ridges left by the potato planter. This tends to compact the soil about the seed pieces, hastens germination, and makes the work of a smoothing

harrow or weeder more effective. The use of weeders lengthwise on the row once or twice is very effective in controlling weeds after the potatoes are planted.

In general, but two systems, level and ridge cultivation, are practiced in the areas producing late potatoes. In the level system the weeder or smoothing harrow is usually used once or twice before the plants emerge. The teeth are angled back so as not to disturb the sprouted seed pieces. Deep cultivation close to the rows follows as soon as the plants are high enough to distinguish the row. For each successive cultivation the side teeth are narrowed and raised, the wings being used to throw the soil around the plants to form a moderate ridge. Cultivation other than for weed control usually is not necessary and is likely to result in actual reduction in yield because of the destruction of roots and the increased loss of moisture.

In the ridge method, riding or walking cultivators are used to loosen the soil and to destroy weeds between the rows. Horse hoes with disks or wings are used after each cultivation to throw up earth and smother weeds along the row. With motorized equipment, cultivation and hilling are done in one operation. In the early cultivation the sprouting seed or young plants are buried once or twice to smother young weeds near the plants and protect the young potato plants from late frosts.

Cultivation should be discontinued as soon as the plants come into full bloom. If weeds are persistent after the plants have reached this stage and the rows are ridged, a spade with adjustable wings should be used to remove the weeds from the middle and the sides of the rows.

IRRIGATION

Unquestionably the most important factor concerned in potato production is rainfall, over which the potato grower has no direct control. Even if the grower planted the best of seed, used the right kind and amount of fertilizer, cultivated and sprayed effectively, and did everything else humanly possible to make conditions favorable for his crop, he formerly had to resign himself to greatly reduced yields when rainfall was seriously lacking or unevenly distributed. For this reason in recent years quite a number of potato growers have resorted to supplemental watering of the potato crop during droughty periods as an insurance against such losses.

For example, in Suffolk County, N. Y., where the irrigation of truck crops has reached a large scale, it is estimated that about 250 potato growers now have installed irrigation systems, chiefly the portable-pipe sprinkler type (fig. 23) ; and further, that in 1945 approximately 15,000 acres out of a total of about 70,000 acres planted to potatoes in this one county was grown under irrigation. In New Jersey, where irrigation of truck crops has been practiced for many years, potato growers have become irrigation-conscious and no doubt will increasingly provide themselves with the means of combating drought when the necessary equipment becomes available.

Cooperative irrigation studies on potatoes conducted by the New Jersey Agricultural Experiment Station and the United States Department of Agriculture in New Jersey over a 5–year period have shown that under irrigation yields averaged about 50 bushels more per acre than without irrigation. In one season the increase was 125 bushels per acre.

Figure 23.—Field of irrigated potatoes on farm of H. R. Talmage and son near Riverhead, N. Y. Note that a portable-pipe sprinkler irrigation line is being assembled in the foreground and that one is in operation in the background.

In Wisconsin, Minnesota, Michigan, Ohio, and Pennsylvania and doubtless in other States in the Northeast and North Central areas, potato growers are resorting to artificial watering to insure themselves against crop losses from drought. Even in central Maine and Aroostook County, Maine, potato growers in recent years have experienced serious losses from drought. Particularly has this been true in central Maine, where during 8 of the last 10 years a period lacking in rainfall occurred. To such an extent has drought prevailed in central Maine that it has led the Maine Agricultural Experiment Station, in cooperation with the United States Department of Agriculture, to conduct an irrigation study there to determine the advantage of irrigation over no irrigation, but only preliminary results are available. In Aroostook County, where there is heavy production of certified seed, a drought during August 1945 seriously affected yields of some of the early varieties. Such experiences are serious when certified seed potatoes are affected because Aroostook County growers ship these to a great many other States. Thus, it is clear that a severe drought in Maine, North Dakota, or Minnesota, three States producing about three-fourths of the certified seed potatoes of the United States, might have serious effects on the yields of table stock throughout the country.

The questions arising about installing an irrigation system are too numerous to be dealt with herein, but if the grower who is considering such a move has an adequate water supply available much of his problem is solved. Kind of soil, slope of land, value of crop, acreage involved, engineering details, and other points will need consideration. By all means the grower should consult the engineering staff of his agricultural college and find out what his neighbors who have installed irrigation systems have learned first hand about how and what to do.

A leading Long Island, N. Y., potato grower with more than 20 years of practical experience in irrigating potatoes and other crops had the following to say about the desirability of irrigation: [23]

I feel very confident after eight years' experience with Portable Overhead Irrigation and 15 years' previous experience with the old Skinner type of irrigation, that we can expect an increase of 50 percent in yield for both potatoes and cauliflower.

Again, if you compare the average yield of potatoes under irrigation for the past 8 years, with the 8 years previous, the average increase in yield would be 65 percent.

Irrigation on Long Island is now no longer an experiment. If I were a banker I would want no better security for a loan to a good farmer than to install an irrigation plant on a good farm where it is practical.

DISEASES CAUSED BY FUNGI AND BACTERIA

BLACKLEG

Blackleg, caused by *Erwinia phytophthora* (Appel) Bergey et al., is a bacterial disease. In some years it is responsible for heavy losses in some of the potato-growing sections. The first symptoms are the rolling of the upper leaves of one or more shoots and the gradual fading of the deep green of the foliage into yellow green. The plant gen-

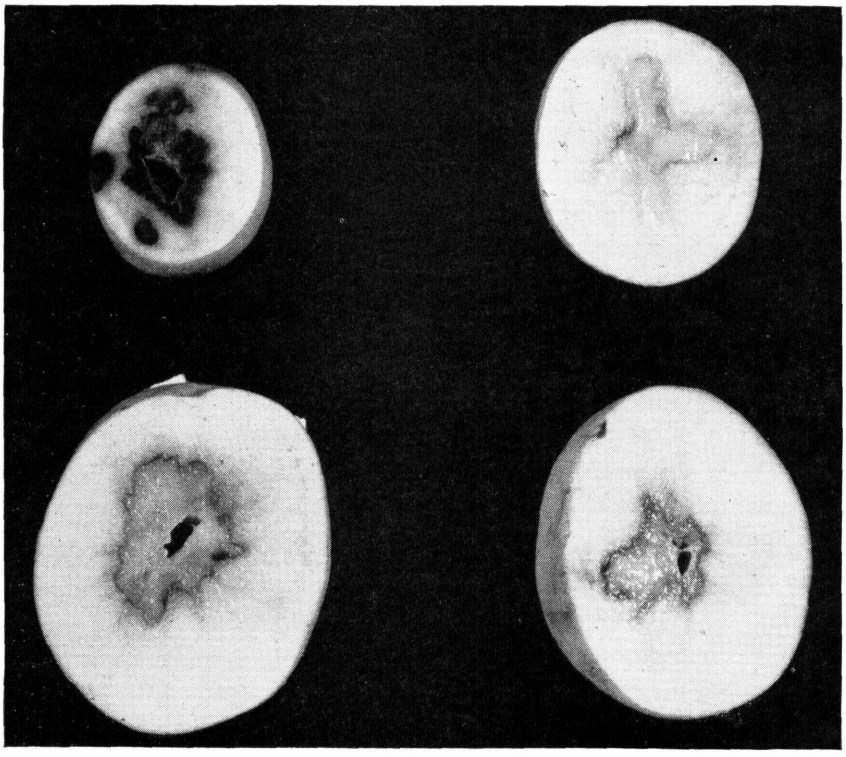

Figure 24.—Early and advanced stages of blackleg in potato tubers, showing discoloration and increase of affected areas.

[23] TALMAGE, H. IRRIGATION ON LONG ISLAND. Hints to Potato Growers, Vol. 25, No. 11, [4 pp.]. March 1945. (See pp. [3, 4].)

erally dies as the base of the stem turns inky black; the blackening extends downward through the stolons into the developing tubers, where it may start a soft rot at the stem end (fig. 24).

Under dry conditions no outward blackening of the stem may be evident, the disease progresses very slowly, and aerial tubers, which arise from enlargement of buds, may be formed on the stems. Plants affected with blackleg may produce potatoes that appear sound but, when planted, such tubers are very likely to carry the disease over to the next season.

To control blackleg, only tubers from fields in which the disease has not occurred should be planted. If cut seed is used, it should be thoroughly corked over to prevent infection from the soil.

RING ROT (BACTERIAL RING ROT)

Ring rot, caused by *Corynebacterium sepedonicum* (Spieck. and Kotth.) Skapt. and Burk., is extremely infectious. It has been found in this country since about 1934 and is now present in nearly all potato-growing States. The symptoms of ring rot usually appear when the potato plants are nearly full grown. One or more stems in a hill may wilt and be more or less stunted, whereas the remainder may appear healthy. The areas between the veins of some of the lower leaves of the infected stems become pale yellowish at first, and within a few days a more pronounced yellowing of these areas, together with an upward rolling of the leaf margins, develops. Finally the plant wilts, and the stem soon dies. If in the advanced stages of the disease the stem is cut across at the base and squeezed, a creamy exudate is expelled.

Infection of the tubers takes place at the stem end. In typical and sufficiently advanced cases there will be a definite separation of the tissue outside of the vascular ring from the tissue on the inside when pressure is applied (fig. 25). Severely soft-rotted tubers, those invaded by secondary organisms, may show internal cracking and browning of the skin.

The use of seed potatoes free from ring rot is the only means of controlling this disease. It is so highly infectious that a knife used to cut an infected tuber may contaminate the next 20 seed pieces cut with it. If evidence is found that the seed potatoes are badly infected with ring rot, they should be used as table stock. In case a lot of potatoes that are to be used to grow table stock exclusively is suspected of containing only a few infected tubers, spread of the disease from one seed piece to another can be prevented by disinfecting the cutting knives. This can be done by dipping the knife in a solution of mercuric chloride (1:1,000) or by soaking it in boiling water for 10 seconds. This procedure is not recommended, however, when potatoes are being grown for seed.

The bacteria may also be carried over in sacks in which infected potatoes have been stored and in refuse in storage cellars. The disease may be introduced into healthy stock by the use of contaminated graders or planters. A picker-planter is a very effective means of spreading the disease. If ring rot was present in stored potatoes during the previous season, storage places should be disinfected with strong solutions of formaldehyde (1 pint of commercial 40-percent formaldehyde to 15 gallons of water) or copper sulfate (10 pounds of copper sulfate to 50 gallons of water). There is no evidence that the disease may be carried over in the soil from one year to the next, except by means of volunteer potatoes.

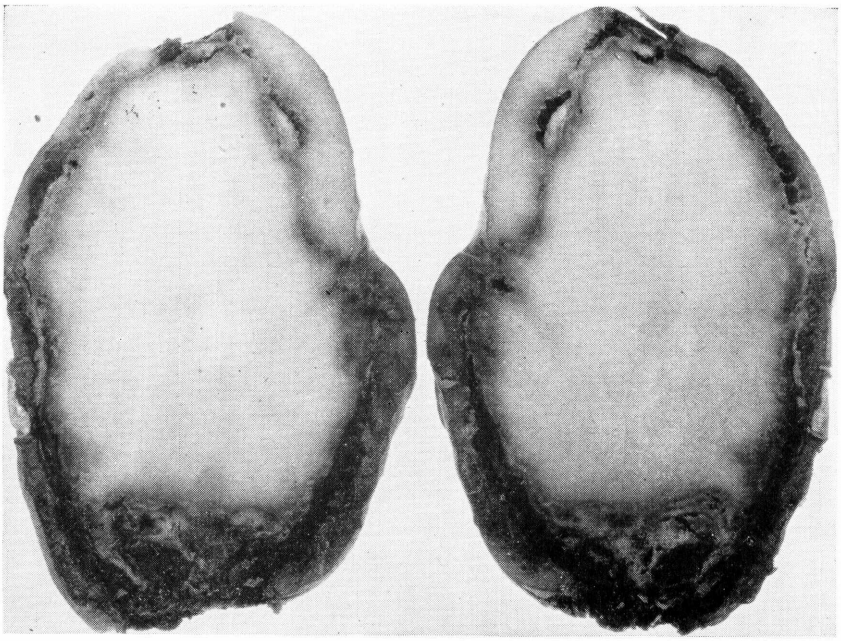

Figure 25.—A potato tuber affected with ring rot sliced lengthwise to show the extent of decay and the separation of the cortex tissue from the core of the tuber. (By courtesy of the Florida Agricultural Experiment Station.)

COMMON SCAB

Common scab, caused by *Actinomyces scabies*, is known to exist in every potato-growing section of the United States. This disease is confined entirely to the tubers. At first the spots are usually small and brownish, but later they enlarge. The lesions may be large and very corky; frequently they extend below the tuber surface and leave deep pits when the corky tissue is removed. Such lesions are known as the pitted type of scab. Sometimes the lesions appear as small russeted areas; they are sometimes so numerous that they almost cover the entire tuber surface. This type of lesion is called surface scab (fig. 26).

Common scab is particularly severe in soils that are about neutral or slightly alkaline (pH 6 or higher), but it causes little if any damage in acid soils below pH 5.5. Applications of fresh manure should not be made just before the field is plowed for potatoes, because such a procedure favors scab development. Likewise, too heavy application of lime or wood ashes tends to induce a soil reaction favoring scab development.

Ordinarily, common scab develops most when the soil moisture is slightly below the requirement for optimum growth of the potato plant. If the soil is of such texture that there is abundant aeration, scab may develop readily, however, even though the soil is very wet.

The common scab organism can be carried from one season to another in the scabby spots on the tubers; therefore seed treatment appears to be the most important means of control. Seed treatment has not been uniformly successful, however, in preventing scab in the succeeding

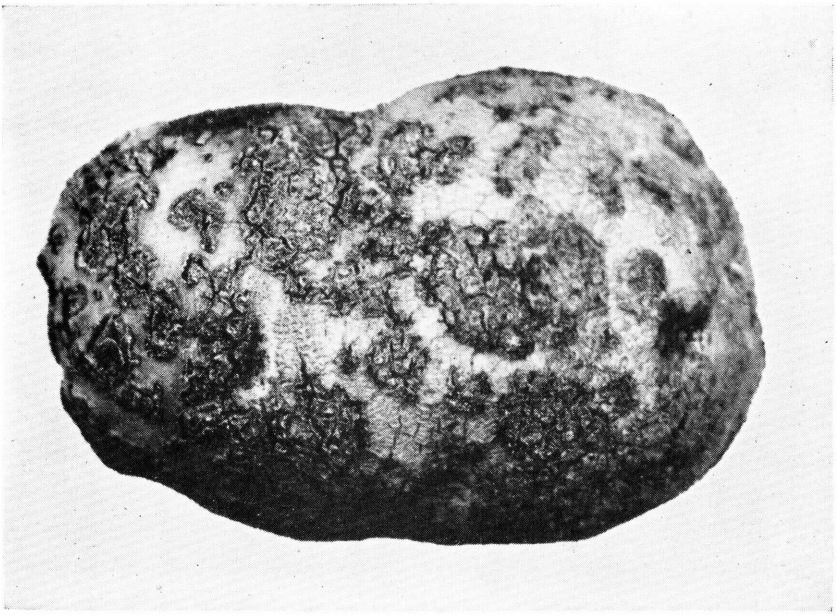

Figure 26.—A potato tuber showing severe infection with common scab.

crop, chiefly because the scab organism can live in the soil for a long time, especially if it is alkaline. If the soil is sufficiently acid, scab generally fails to develop even if badly infected seed is planted.

The development of scab-resistant varieties appears to provide the best future possibility of successfully growing potatoes on scab-infested land. Considerable progress is being made by the United States Department of Agriculture and the State agricultural experiment stations in developing varieties highly resistant to scab.

RHIZOCTONIA CANKER (BLACK SCURF)

The fungus (*Rhizoctonia solani*) that causes rhizoctonia canker, or black scurf, ordinarily shows up on tubers as small brownish-black bodies closely adhering to the skin. They may be as small as a pinhead or as large as a half pea. These particles, known as sclerotia, represent the resting stage of the fungus. When introduced into the soil on seed tubers, these sclerotia produce an abundance of fungus threads that attack the young shoots, roots, stolons, and tubers of the new crop. Often the sprouts are attacked and killed by the fungus before they reach the surface of the ground. Cankers may also occur on the stolons, cutting the tubers from the main stem and thus preventing their further development. Cankers occasionally develop on the stems of older plants, but they do not extend so deeply into the interior as to destroy the parts above. These cankers show at the surface of the soil or below as irregular, elongated, brown areas (fig. 27). The vines become reddish yellow; the leaves have a tendency to roll; the stalks become swollen, especially at the nodes; and the buds enlarge sometimes to the size of small tubers, giving rise to the term "aerial tubers."

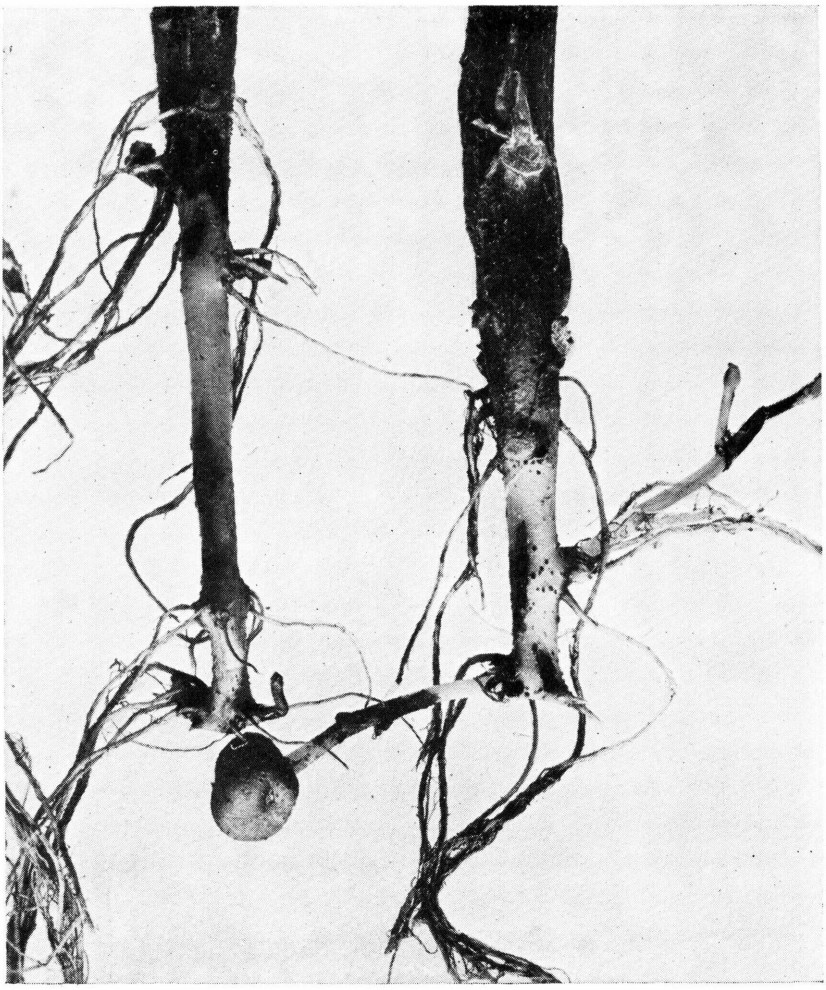

Figure 27.—Brown, dead, cankerous areas on stems and on stolons of potato, due to infection originating from sclerotia on tubers or from the fungus that may overwinter in the soil.

The causal fungus is able to live for a long time even in dry soils. Although greatest injury to the sprouts occurs at temperatures below 70° F., lesions may be produced at any temperature from 48° to 80° if other conditions are favorable for growth of the fungus. The organism can overwinter in the soil and also as sclerotia on the surface of the tuber; since there are many other cultivated plants and weeds susceptible to this organism, in addition to potatoes, crop rotation is not always as effective in eradicating the causal organism as might be expected. Planting only tubers free from *Rhizoctonia* infection or treating slightly affected seed tubers with mercuric chloride or other disinfectants, as described on page 23, combined with crop rotation and shallow planting, provides the best method of control.

LATE BLIGHT

Late blight, caused by *Phytophthora infestans* (Mont.) DBy., is one of the most destructive diseases in the New England and North Central States. The disease is known as late blight because in most sections of the country it attacks plants at the blossoming stage or afterward. Late blight appears on the leaves as pale-green, irregular spots. In moist weather these increase in size rapidly, the centers of the spots die and then turn brown or black, and on the lower sides of the leaves a ring of white mildew sometimes forms around the dead areas. The stems may be affected, and under humid conditions the entire vine may be killed and blackened in a couple of days. Under favorable warm and moist weather conditions, the disease spreads rapidly, with the result that all the plants in the field may be killed in a few days. The decaying tissues give off a characteristic odor, which becomes very pronounced in fields that are severely attacked.

The organism also readily attacks the tubers, which become infected in the soil through contact with spores washed in from blighted foliage. When late blight tuber rot develops in the soil it spreads irregularly from the surface of the tuber through the flesh, like the diffusion of a brown stain. At first the affected tissue is dry and firm, but infected tubers are readily invaded by bacteria and fungi which cause soft rots that destroy them. This happens especially in low, wet spots. Under storage conditions the disease is typically a dry rot; the irregular, sunken patches formed under conditions favorable for their development, such as high humidity and temperature, may involve the entire tuber. At low storage temperature the patches usually remain rather firm and frequently have a metallic tinge, especially at the border of healthy tissues.

The late blight fungus may grow from a diseased seed tuber up the stems to the surface of the soil, sporulate, and then cause infection of the foliage. Ordinarily, a very low percentage of infected tubers develop shoots infected with late blight. The reason is that under field conditions the diseased shoots often die before they emerge from the soil. This is especially true if the tubers are planted deep.

Observations in Maine and other States have demonstrated that cull piles of potatoes dumped outside potato storage houses, along the railway tracks, or on farms are a primary source of infection. These cull piles often contain a high percentage of infected tubers, some of which develop infected sprouts. The spores from these may infect sprouts of healthy tubers until practically the entire pile becomes infected. Such infections generally develop during the early part of the growing season. The spores may be carried by the prevailing winds to the neighboring fields and infect the young potato plants before the farmers have begun to spray. Since cull piles are one of the chief early sources of late blight infection, their elimination will do much to prevent the spread of the disease. These potato dumps should be treated with a herbicide to destroy the potato sprouts or with bordeaux mixture or copper sulfate solution to control infection. Disposing of waste potatoes by boiling, incineration, or feeding to livestock, instead of establishing cull piles, will, however, prevent development of infected plants and render unnecessary the subsequent job of destroying the tops or spraying.

Spraying for the control of late blight should begin when the plants are about 4 inches high and before the disease develops (fig. 28). The

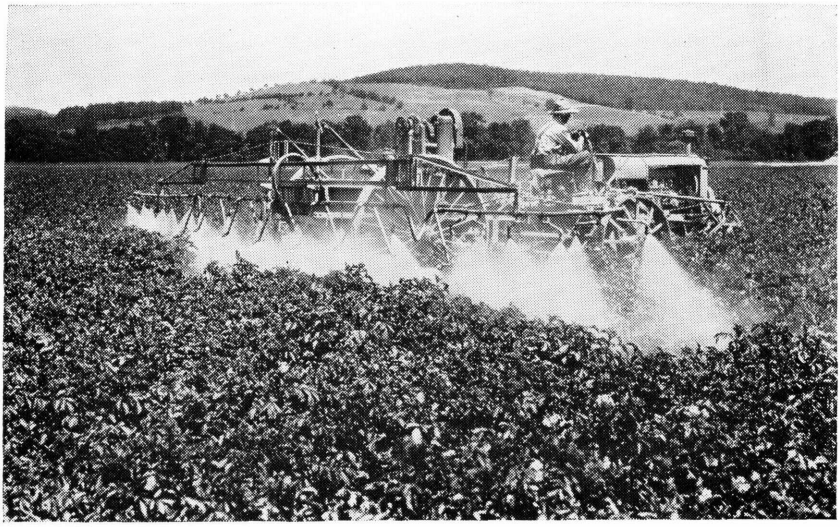

Figure 28.—Spraying potatoes wholesale, Tioga County, N. Y.

foliage should be thoroughly covered with a layer of bordeaux mixture, or in some parts of the country with Dithane, a new organic fungicide. A detailed account of methods of preparing and applying sprays is given on page 52.

Sebago, one of the new late varieties developed by the United States Department of Agriculture, is moderately resistant to late blight and during years of moderate epidemics will produce a good crop with limited spraying.

EARLY BLIGHT

Early blight, caused by *Alternaria solani* (Ell. and G. Martin) Sor., and also known as leaf spot, occurs earlier in the season than late blight; it is also rather common, however, late in the season if weather conditions are favorable for its development. It attacks the potato stems and leaves, causing brown spots which develop concentric rings or markings as they enlarge and produce a target-board effect (fig. 29). When the spots are numerous they kill the leaves and consequently reduce the yield of potatoes.

Sometimes the early blight fungus causes small, shallow, more or less circular, decayed lesions on the tubers. The margin of the diseased area is raised somewhat, and the immediately adjoining skin is slightly puckered. The lesion may afford an entrance for saprophytic molds that complete the rotting of the tuber. This is especially true if seed potatoes are shipped to Florida or other southern points where the high temperature is favorable for the growth of decay organisms.

Early blight can be successfully controlled by thorough and early spraying with bordeaux mixture. Dithane, when combined with zinc sulfate, has given excellent control in preliminary trials.

WILTS

Potato wilts may be caused by a number of species of *Fusarium* and by *Verticillium albo-atrum* Reinke and Berth. The symptoms caused

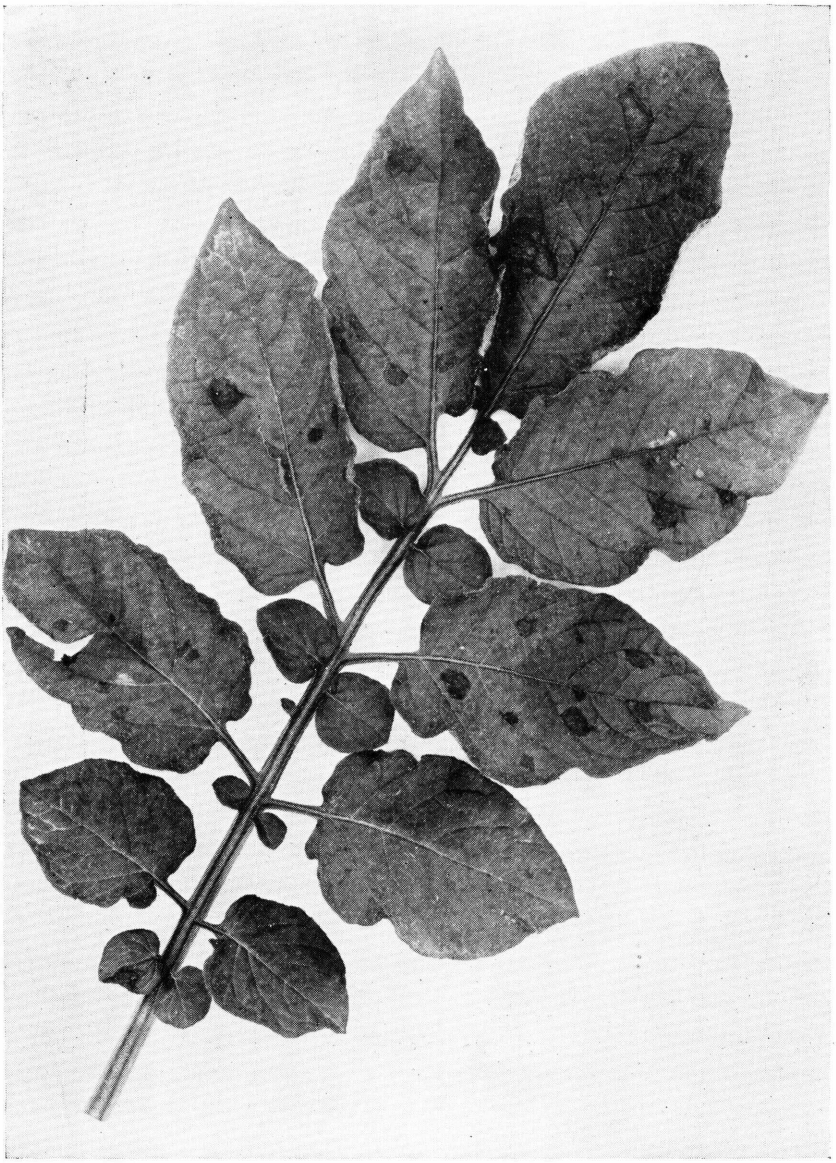

Figure 29.—Early blight lesions on potato leaf.

by *Fusarium oxysporum* Schlecht. and *Verticillium albo-atrum* are very similar. Attacked plants may wilt rather suddenly and die in a comparatively short time, or they may show the effects slowly and succumb very gradually. Plants produced from infected tubers may be stunted from the beginning and die without reaching average size. The vines die prematurely, but the stalks remain upright except for the tips which may droop. The stems of affected plants are discolored in the interior.

The type of wilt caused by *Fusarium solani* var. *eumartii* (Carpenter) Wr. is characterized by a discoloration of the tops and a flecking of the pith of the stems. The first indication of the disease on the foliage is the appearance of small light-green areas between the veins of the leaflets, which give them a mottled appearance. These gradually turn yellow. This yellowing is often accompanied by a bronzing of the upper surface of the leaf in smaller, irregular spots.

The fungi causing wilts are able to pass the winter in affected tubers in the soil. It is not known how long they can persist in the soil, but severe attacks have occurred in soils in which potatoes had not been grown previously. Since the fungi causing wilts are also carried over in seed potatoes, only wilt-free seed potatoes should be used.

DRY ROTS

Dry rots, caused by *Fusarium coeruleum* (Lib.) Sacc. and *F. trichothecioides* Wr., are generally referred to as storage dry rots; one form or another is likely to occur wherever potatoes are stored. The one caused by *F. coeruleum* seems to be the commonest. This organism generally enters the tuber through wounds and produces large sunken pockets or a wrinkled decay. Numerous bluish or whitish points, or protuberances, are formed on the surface of the decayed parts.

The powdery dry rot, which is caused by *Fusarium trichothecioides*, is limited chiefly to localities having warm dry summers and is prevailingly western in distribution.

Many virgin and cultivated soils are infested with these organisms; different types predominate according to the conditions. Scrapings from soil adhering to tubers have in many cases been shown to contain the organisms that cause dry rots. Even though these fungi are present on tubers, they do not cause infection unless temperature and moisture conditions are favorable for the germination of the spores and growth of the fungi.

To avoid tuber rots, the potatoes should be handled carefully in order to reduce mechanical injury to a minimum. The superficial moisture should be removed from the tubers as promptly as possible after they are dug, and they should be kept dry at least during the first 4 weeks of storage. The dry rot fungi will not grow at temperatures above 86° F. or below 41°. The best growth of the fungi is obtained at about 75°, and potatoes will rot most rapidly at this temperature. At temperatures between 55° and 41° rot progresses very slowly.

VIRUS AND VIRUSLIKE DISEASES

No other group is more responsible than the virus diseases for failure of potato fields to meet the requirements for seed-potato certification. In this group are such diseases as mild mosaic, rugose mosaic, leaf roll, spindle tuber, and yellow dwarf.

Temperature may greatly modify the symptoms on plants affected with virus diseases. If a plant affected with mild mosaic is grown under high temperature, the symptoms will completely disappear and the plant will seem to be healthy; however, it still retains the virus and remains a source of infection. When the temperature drops again the symptoms will reappear. This is one of the reasons why seed potatoes are grown in regions where a low temperature prevails,

so that infected plants may show symptoms distinctly and can be readily identified and rogued to prevent spread of viruses to healthy plants.

Aphids are the most effective carriers of potato viruses. When aphids feed on a diseased plant and then later on a healthy one they may transmit virus diseases. Winged aphids may carry the disease for a distance of 200 yards or more.

Since plants affected with a virus disease form tubers which produce diseased plants, it is very important in the production of seed potatoes to remove affected plants as soon as the disease can be recognized so as to reduce to a minimum the spread to healthy plants. This is best accomplished in an isolated seed plot planted in tuber units.

MILD MOSAIC

Mild mosaic can be recognized by a mottling in the green of the leaf, on which yellowish or light-colored areas alternate with the normal

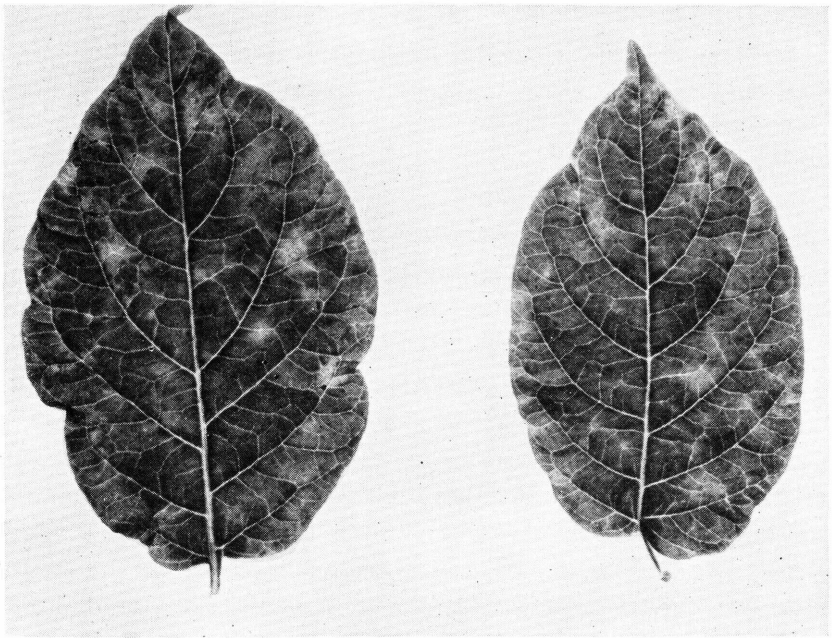

Figure 30.—Leaflets from a Green Mountain potato plant infected with mild mosaic. The yellow patches do not follow the veins but are interspersed in the normal green of the leaves.

green, accompanied by a slight crinkling (fig. 30). The diseased plants droop and die prematurely, especially during hot and dry weather.

The only way in which mild mosaic can be avoided is by the selection of tubers from healthy plants for seed purposes. The United States Department of Agriculture, in cooperation with State agricultural experiment stations, has developed and introduced the varieties Katahdin, Chippewa, Houma, Sebago, and Earlaine, which do not contract mild mosaic in the field.

Figure 31.—Potato plants showing current-season symptoms of rugose mosaic. Tubers from affected plants will produce typical rugose mosaic plants.

RUGOSE MOSAIC

Rugose mosaic, a more serious disease than mild mosaic, is entirely distinct from it. Although its symptom pattern is a distinct mosaic, rugose mosaic differs from mild mosaic in that the mottled areas are smaller, more numerous, and closer to the main veins. Although high temperature will also mask the mottling, the identity of the disease can always be determined by the crinkling and rugosity of the leaves. The veins of the lower leaves often show necrotic areas as black pencillike lines and have a tendency to be somewhat brittle. In the field rugose mosaic is spread from diseased to healthy plants by aphids. From 2 to 3 weeks after infection has taken place, current-season symptoms will develop. These are characterized by a burning and discoloration of the leaf veins and blades, brittleness, leaf dropping, and premature death (fig. 31). When tubers from such plants are planted they give rise to typical rugose-mosaic-infected plants.

The disease is subject to control by rigid roguing. To be effective, the roguing must be started early and must be repeated often, preferably about once a week in the early part of the season.

LEAF ROLL

Leaf roll is characterized by the upward rolling of the leaflets lengthwise so that the midrib remains at the middle of the trough thus formed. The young plants show rolling first of the lower leaves and then of progressively higher leaves until eventually all leaves may be rolled (fig. 32). Other symptoms include dwarfing, rigidity, leathery texture, chlorosis, reddish or purplish discoloration of the affected leaves, and reduction in the number and size of the tubers.

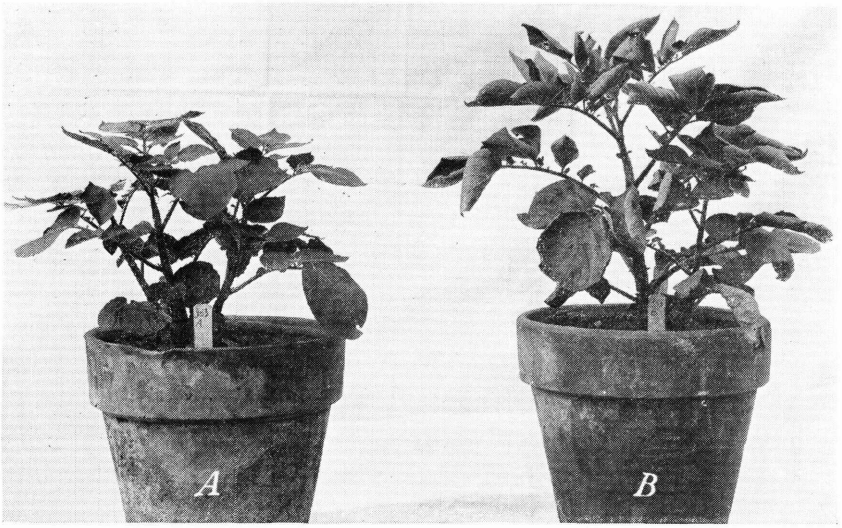

Figure 32.—A, Healthy potato plant. *B,* Plant infected with leaf roll; observe the upward rolling of the leaflets.

If plants become infected during the current season, they may show rolling only in the upper leaves. In the tubers of certain varieties another symptom of current-season infection is net necrosis. This consists of small brown strands of discolored tissue extending throughout the interior of the potato-tuber tissue at the stem end. This condition so affects the grade of table stock that if net necrosis in excess of a designated percentage occurs in a lot of potatoes, these cannot be sold as U. S. No. 1 grade. The Green Mountain and Irish Cobbler varieties develop net necrosis readily, whereas some of the newer varieties such as Katahdin, Sequoia, and Chippewa remain practically free from the disease even with an appreciable amount of leaf roll in the tops.

Leaf roll may spread very rapidly. Roguing in isolated tuber-unit plots gives good control, but it has to be done rigidly and efficiently. In areas where aphids are abundant late in the season, early harvesting is desirable for the production of disease-free seed potatoes.

SPINDLE TUBER

The name "spindle tuber" comes from the shape of the tubers produced by plants affected by this virus disease. In most varieties the tubers become elongated and pointed at one end or both (fig. 33). In some of the round varieties, such as Triumph and Irish Cobbler, the tubers become elongated but not pointed at the ends. Long tubers, especially, become spindling and pointed at the stem end. Shallowness of eyes and increase in their number are characteristic of this disease.

In affected plants the most prominent symptoms are erect, somewhat spindly growth, stunted size, and generally a noticeably darker green of the foliage. The leaves usually are set at an acute angle with the stem and do not curve outward like normal ones, giving the plant an appearance of standing erect.

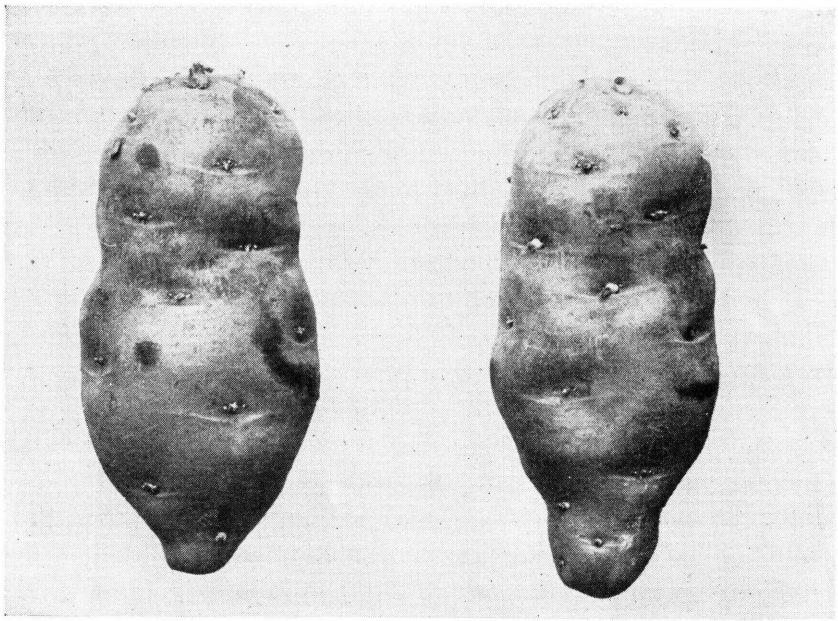

Figure 33.—Green Mountain tubers affected by spindle tuber. Affected potatoes are elongated and more pointed at the stem end than normal ones.

Since it is sometimes difficult to recognize spindle tuber in all affected individual plants in a mass plot, roguing in tuber-unit seed plots is particularly desirable for the control of this disease.

YELLOW DWARF

Yellow dwarf is not widespread but has been reported from some of the Eastern and Middlewestern States. The foliage of affected plants takes on a yellowish-green color, whereas the upper surface of the leaves becomes slightly rugose. Dying from the tip downward is characteristic, but under some conditions this symptom may be absent. High temperature and low humidity tend to hasten the death of affected plants. Brown spots in the pith of the stem are common; they appear shortly after yellowing of the foliage and may eventually extend the entire length of the main stem.

The effect of yellow dwarf on the tubers varies. Infected plants often produce small, misshapen tubers, which in cross section show small necrotic areas scattered throughout the flesh.

This disease can be transmitted by the clover leafhopper (*Aceratagallia sanguinolenta* (Prov.)). This insect retains the virus during the winter and infects healthy plants in the spring. Therefore, it will be desirable to plant potatoes some distance from clover fields. No control measure is known except the planting of disease-free seed.

PURPLE-TOP WILT

Purple-top wilt has been known under various names for at least 30 years, but it was not known until very recently that it is caused by a virus transmitted by the leafhopper *Macrosteles divisus* (Uhl.) from asters and other hosts of aster yellows.

Figure 34.—Symptoms of purple-top wilt on two shoots of the Chippewa variety. Some of the leaves were removed to show swollen stems of the axillary shoots. (By courtesy of the West Virginia Agricultural Experiment Station.)

Leaflets on infected plants usually show a faint purpling. In intense light the purple color is generally increased in those varieties where pigmentation is characteristic. Pigmentation is generally evident also in the stems of diseased plants, especially in the Rural New Yorker No. 2 variety. An abnormal number of axillary shoots which become swollen at the base and often form distinct aerial tubers (fig. 34) develop. A plant generally wilts within 2 weeks after the symptoms appear, and death may soon occur. An internal necrosis of tubers extending from the stem end is characteristic of the disease on Rural New Yorker No. 2 in West Virginia, but it may be absent on other varieties and on Rural New Yorker No. 2 in other regions. Occasionally tubers from infected plants are flabby.

Purple-top wilt is not transmitted as such through the tubers, but the tuber progenies of affected plants are much less vigorous than those of healthy plants.

DISEASES DUE TO NONPARASITIC CAUSES

In the group of diseases due to nonparasitic causes are included those that seem to be due to unfavorable environmental conditions and are not known to be caused by any virus, fungus, bacterium, or insect.

INTERNAL BROWN SPOT

Internal brown spot is characterized by irregular, dry, brown spots or blotches scattered through the flesh of the potato (fig. 35). These brown spots consist of a group of dead cells free from bacteria and fungi. No definite foliage trouble is associated with this disease.

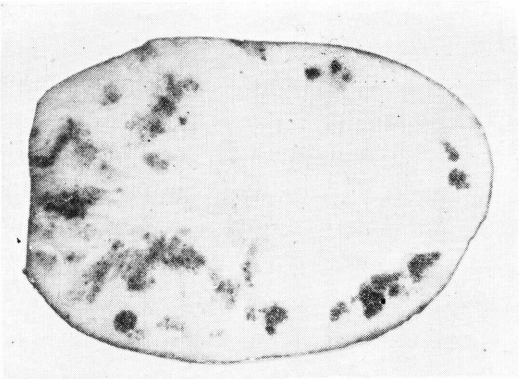

Figure 35.—Internal brown spot of potato.

Not much is known about the cause of this trouble, but there seems to be a close relation between the disease and the lack of available soil moisture late in the growing season. Some varieties develop this condition much more readily than others.

No measures have been worked out that will prevent the occurrence of internal brown spot in the field. Favorable cultural conditions may, however, reduce the severity of this disease. Affected potatoes should not be used for seed because they may give rise to weak plants.

FROST OR FREEZING NECROSIS

If exposure of potatoes to freezing temperatures leads to ice formation in the tissues, it may cause a variety of symptoms known as freezing injury. Sometimes these symptoms are general and readily apparent externally; at other times they are localized internally and are visible only upon cutting. The internal type is known as frost or freezing necrosis, whereas the external is known as freezing. Both types of symptoms can be detected only after thawing.

Tissues killed by freezing are very wet and usually become infected with bacteria which cause a foul-smelling slimy or sticky rot if the tissues thaw in a warm, humid atmosphere; or the tissues may dry down to a mealy or tough, leathery, granular, chalky mass if they thaw in cold or dry air. If only one side of a tuber is frozen, the killed portion frequently is sharply set off from the unaffected area by a purplish or brown line of corky tissue. Often fusarium tuber rot sets in before the unaffected cells are cut off by the corky layer.

Generally, however, freezing necrosis is marked by internal discoloration, of which there are several types. One, the ring type, is limited to the vascular ring and immediately adjoining tissues. Another, the net type, is marked by more or less blackening of the vascular tissue and the fine strands that extend from the vascular tissue into the interior pith and outer tissues (fig. 36). Finally, there is a blotchy type, marked by irregular patches ranging in color from an opaque gray or blue to sooty black, which may occur everywhere in the tuber. When these blotches are in the outer tissues they may be apparent externally in clear tubers with white skins. This is the only type of freezing necrosis that may be visible externally. Tubers affected

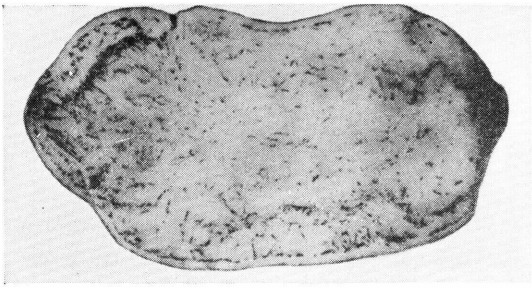

Figure 36.—Frost or freezing necrosis of potato.

with any or all of these types of freezing necrosis generally shrivel or wilt more than nonaffected tubers. However, excessive shriveling alone cannot be relied upon as a sign of freezing necrosis.

If tubers are exposed to temperatures that are low but not low enough to cause ice formation, sugars increase and the tubers become sweet. This sweetness disappears if these tubers are kept at temperatures above 40° F. Frozen tissues, however, are no sweeter than uninjured ones; therefore, sweetness of tubers is not a sign of freezing injury. Potato tubers will not freeze at 32°. The critical temperature, that is, the temperature at which ice begins to form, lies between 29.5° and 26.6°. It is impossible to forecast the critical temperature for a particular tuber because there are differences in the individual susceptibility to freezing. The length of exposure to freezing temperatures is also an important factor. It is not advisable to plant tubers showing severe freezing necrosis, as tubers that have been severely affected usually rot in the soil before sprouting. Potatoes showing only slight freezing necrosis may ultimately produce normal plants, but in general they should not be planted if sound seed stock can be obtained. To prevent freezing injury, tubers should not be exposed to temperatures below 32°.

STEM-END BROWNING

The cause of stem-end browning has not yet been fully determined, but from present knowledge it is considered due to nutritional disturbances. There is no evidence to indicate that the trouble is transmissible. In other words, the planting of tubers affected with stem-end browning is not reflected in reduced yields in comparison with those from clear-flesh tubers. Seasonal conditions, cultural factors, use of certain kinds of fertilizer (chiefly those containing a large content of chlorine), and storage temperatures, particularly the last-named, have been found to have some effect on its prevalence. Stem-end browning may be confused with net necrosis. However, the brown discoloration associated with stem-end browning as a rule does not penetrate the tuber more than half an inch, whereas that of net necrosis is usually deeper (fig. 37).

While the stem-end browning does not affect the edible quality of tubers or their value for seed purposes, it does impair their market value because of inspection restrictions.

Green Mountain and Irish Cobbler varieties are particularly susceptible to stem-end browning, but the trouble has not been found in

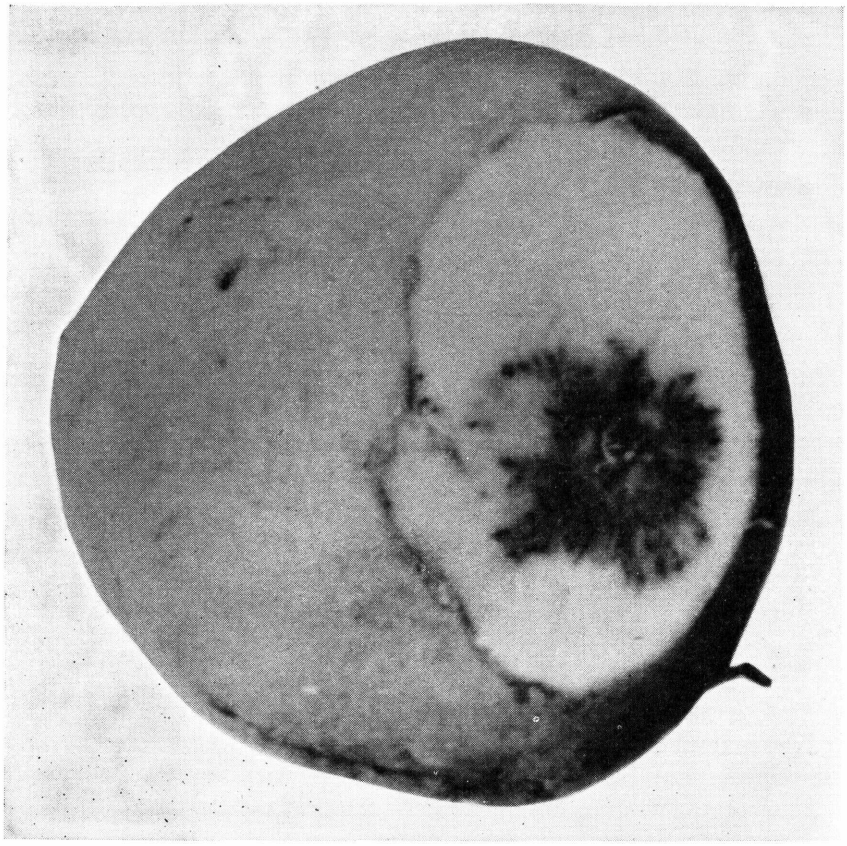

Figure 37.—Stem-end browning of potato, apparently the result of some nutritional upset rather than a virus or fungus disturbance. (By courtesy of the Maine Agricultural Experiment Station.)

some of the newer varieties, such as Chippewa and Katahdin. The chief control measures so far indicated are the planting of nonsusceptible varieties and the use of proper storage temperatures.

SPRAYING AND DUSTING

SPRAYING

In order to control some of the leaf diseases of potato, such as late and early blights, spraying (fig. 28) has to be practiced. Formerly an 8–8–100 or a 10–10–100 bordeaux formula was used, but now a 10–5–100 formula is generally used in the Eastern States. This nearly neutral spray has given as good or better yields than is obtained with the formerly used alkaline spray. The materials required for making 10–5–100 bordeaux mixture are copper sulfate 10 pounds, lump lime 5 pounds (or 7 pounds of hydrated lime), and 100 gallons of water. A convenient method of making up this spray mixture is to dissolve 10 pounds of pulverized copper sulfate in 50 gallons of water by

suspending it in a sack near the top of the water overnight or in a small quantity of hot water which is then diluted to 50 gallons; slake the 5 pounds of lump lime gradually in a small amount of water and dilute the milk of lime to 50 gallons, or mix the 7 pounds of hydrated lime in 50 gallons of water; then pour the two solutions together in a third barrel and stir vigorously. The resulting bordeaux mixture is of a milky-blue color. If it is impossible to spray at once, 1½ ounces (2 heaping tablespoonfuls) of sugar dissolved in a small amount of water should be added to each barrel of 100 gallons of spray mixture. This will keep the spray mixture in good condition for a long time; otherwise the spray will be worthless after about 24 hours.

Calcium arsenate or lead arsenate is added at the rate of 4 pounds to 100 gallons of water when needed to control Colorado potato beetles and flea beetles. DDT, a recently developed insecticide, can also be mixed with bordeaux mixture (p. 55).

To be effective, spraying must sometimes be started when the plants are 4 to 6 inches tall and be continued at regular intervals throughout the growing season. During some years and in some localities 5 or 6 applications are sufficient; under other conditions 10 to 12 applications are none too many. On the other hand, in some years spraying may not be necessary, at least not until disease appears. The State agricultural college or the local extension service should be consulted as a guide to local practices, as spray programs may vary even in different parts of the same State.

It is good practice to keep all new growth protected with the fungicide and to renew the application on the older growth. To give the vines a good protective coating, an application of 60 to 75 gallons to the acre is required when the plants are small and 100 to 125 gallons when they are large.

During the war years considerable research was conducted on the development of new organic fungicides. One of these, Dithane, has been promising for late blight control. The results obtained in Dade County, Fla., showed Dithane plus zinc sulfate and hydrated lime (tank mix) to be very satisfactory for the control of late blight, provided the spray is thoroughly applied at intervals of not more than 8 days, since it quickly loses its effectiveness after this interval. It is reported less injurious than bordeaux mixture, and plants sprayed with it significantly outyielded those sprayed with bordeaux in the Florida tests.

One of the draw-backs of this new fungicide is that it is fairly unstable, and the results obtained in different sections of the country are not always consistent. In some of the Northern States Dithane was not effective in controlling late blight. This organic fungicide appears to be promising in certain sections of the country, but sufficient information on its behavior is not yet available to make a general recommendation for its use. Before it is, it will be advisable to consult officials at the State agricultural college to learn whether it has been tested in the State.

DUSTING

Many growers prefer to apply copper-lime dust rather than bordeaux mixture for the control of foliage diseases. Dusting is more easily done than spraying and requires less expensive and less complicated machinery. Much experimental work in a number of States

has demonstrated that a dust properly applied will give almost as good control of late blight as a spray. A very satisfactory dust for potatoes is a mixture of monohydrated copper sulfate and hydrated lime with powdered lead arsenate or calcium arsenate added when an arsenical poison is necessary (p. 55). The materials must be so fine that 95 percent of the mixture will pass through a 200-mesh sieve. The percentages of copper sulfate used vary somewhat, but 20 percent is considered satisfactory. When an arsenical is needed, either 7 to 15 percent of lead arsenate or 10 to 25 percent of calcium arsenate replaces an equal percentage of the lime. It is also possible to purchase the dust already mixed.

The amount of dust needed depends on the size of the plants and the percentage of copper in the dust. The amount of copper is approximately the same as that found in the bordeaux mixture needed to give complete coverage. Generally the same number of applications of dust as of spray will be needed during the season. If the dust is applied when the leaves are dry, it is likely to be blown off. It is therefore desirable to apply it early in the morning, when the leaves are covered with dew. When the copper-lime dust comes in contact with moisture on the leaf, the particles of copper sulfate and of lime combine to form a bordeaux mixture.

Dusting is often done on peat land on which it is frequently impossible to operate heavy sprayers. Also on hilly land or where it is difficult to get water to operate sprayers, dusting is often preferable.

INSECT ENEMIES OF POTATOES [24]

The common insect pests of potatoes in the Northeastern and North Central States are the Colorado potato beetle, the potato flea beetle, aphids, the potato leafhopper, and wireworms. The seed-corn maggot and white grubs are occasionally troublesome in some districts.

COLORADO POTATO BEETLE

The Colorado potato beetle (*Leptinotarsa decemlineata* (Say)) is one of the most widespread and destructive insect pests of potatoes in this country. The insect first appears in the spring in the form of the adult, or hard-shelled beetle, about two-fifths of an inch long. It is stout and round in general shape and light yellowish in general color, with 10 black stripes down its back. The female beetles lay their orange-red eggs in batches of 5 to 70 on the under side of the potato leaves. In 4 to 9 days these eggs hatch into small larvae. These larvae have soft bodies that range in color from lemon to reddish brown and are marked with 2 rows of black spots on each side. The head and legs are black. The larvae feed greedily and grow rapidly for approximately 2 weeks, during which time they devour large quantities of potato foliage. At the end of this period they reach full growth and are about three-fifths of an inch long. At this stage they drop from the plant and enter the soil, where they change to the inactive, or pupal, stage. They remain in this stage for a short time, the length of time depending upon the time of season and the locality. At the expiration of this period the adult, or beetle, emerges from the pupa and flies to a potato field to start a new generation of the pest.

[24] Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

There may be 1 or 2 generations of this insect in any given locality each year, depending upon climatic conditions.

The Colorado potato beetle can be controlled with insecticides containing arsenicals or rotenone. For sprays, use 1 pound of paris green and 4 pounds of hydrated lime, or 4 pounds of calcium arsenate, or 4 pounds of lead arsenate, or 4 pounds of derris or cube root containing 4 to 5 percent of rotenone, to each 100 gallons of water. If a bordeaux mixture is to be applied for the control of diseases, add the arsenicals, at the quantities stated, to each 100 gallons of the bordeaux mixture. For dusts, use at the rate of 1 pound of paris green or lead arsenate to 12 pounds of hydrated lime or equal parts of calcium arsenate and hydrated lime, or a dust mixture containing 0.75 percent of rotenone. Although the insecticides containing rotenone are effective in controlling the Colorado potato beetle, they are more expensive than the arsenicals.

Results obtained from the use of DDT on the 1945 potato crop in Maine [25] indicated that this insecticide controlled infestations of the Colorado potato beetle, as well as of the potato flea beetle, and substantially reduced the numbers of aphids. Although much more work remains to be done before final recommendations can be made for the use of DDT against these insects, growers wishing to use this insecticide will benefit from the suggestions made in this section.

DDT may be used against the Colorado potato beetle on potatoes as a dust or as a spray in the form of a suspension or an emulsion. For a dust mixture use 20 to 25 pounds of a 3-percent DDT dust per acre as soon as the beetles are observed in the field. If a second application becomes necessary, a slightly larger quantity of the dust may be required, depending on the size of the plants. If a spray is preferred, either a suspension made with 1½ pounds of a wettable powder containing 50 percent of DDT per 100 gallons of water or an emulsion containing ½ pound of DDT in an oil base, plus an emulsifier, per 100 gallons of water may be used for this purpose.

Experience thus far indicates that DDT may be used in sprays with bordeaux mixture and other copper fungicides and in dusts with copper fungicides that do not contain lime. Until more information is available, however, DDT should not be used with copper-lime dusts, as dusts are ordinarily mixed some time before use and continued contact with the lime may hasten the deterioration of the DDT.

Since potato aphids may be present when it becomes necessary to apply insecticides against the Colorado potato beetle, many growers may prefer to use one treatment for the combined control of these insects. In such cases the suggestions given for the use of DDT in aphid control should be followed (p. 57).

DDT is known to be a harmful substance and, especially when dissolved in oil or when coming in contact with greasy hands, it may be absorbed in harmful quantities through the skin. Great care should be taken, therefore, to avoid contact with oil emulsions containing DDT, and it is advisable to wear gloves. If DDT is spilled on the skin or the clothing, it should be washed off at once.

[25] Experiments conducted cooperatively by the Bureau of Entomology and Plant Quarantine and the Bureau of Plant Industry, Soils, and Agricultural Engineering of this Department and the Maine Agricultural Experiment Station.

In handling, mixing, and applying all insecticides, special care should be taken not to inhale excessive quantities at any time. Respirators affording protection to the entire face are available and should be used when much spraying is to be done. After work with insecticides the hands or any other exposed parts of the body should be washed thoroughly.

POTATO FLEA BEETLE

The potato flea beetle (*Epitrix cucumeris* (Harr.)) not only causes reductions in the yield of potatoes in some sections of the North because of the feeding of the beetles on the foliage, but the attacks of the larvae on the potato tubers have resulted in producing potatoes of inferior quality. The adult of the flea beetle is about one-sixteenth of an inch long, is black in general appearance, and has yellow legs. When disturbed, it jumps quickly and may readily disappear from sight. It feeds on both surfaces of the leaves, producing numerous small holes. Severely injured leaves may dry up and fall from the plant. The immature form of the flea beetle is a slender, white, wormlike larva approximately one-fifth of an inch long. It feeds on the roots and tubers. On the tubers its feeding results in tiny tunnels near the surface of the tubers and pimplelike scars on the surface.

The most general control measure for the flea beetle is to spray thoroughly with bordeaux mixture to which is added calcium arsenate at the rate of 4 to 5 pounds for each 100 gallons of spray mixture. Use the larger amount of calcium arsenate for close seed spacing. It is particularly important to use the poison in the early sprays. If spray equipment is not available, dust with a mixture of calcium arsenate, monohydrated copper sulfate, and hydrated lime (25–20–55). Dusting is not so effective as spraying, however, for the control of this insect. Experience thus far indicates that the potato flea beetle can be controlled with DDT applied in the same manner as directed for the Colorado potato beetle (p. 55).

APHIDS

Several species of aphids, or soft-bodied plant lice, attack potato foliage. The potato aphid (*Macrosiphum solanifolii* (Ashm.)) varies in color from green to pink and is often called the pink-and-green potato aphid. The green peach aphid (*Myzus persicae* (Sulz.)), which is also commonly found on potatoes, is green, as its name indicates. Two other species of aphids commonly found on potatoes in some districts are the buckthorn aphid (*Aphis abbreviata* Patch), which is small and yellow, and the foxglove aphid (*Myzus convolvuli* (Kltb.)), which is pale green. When abundant, these aphids not only reduce the yield of tubers by sucking the juices from the foliage but also transmit leaf roll and other virus diseases.[26]

Aphid infestations are difficult to control, but if control operations are begun at the early stages of the infestation by spraying with a mixture containing 1 pint of nicotine sulfate to 100 gallons of bordeaux mixture, good results can be obtained. Another effective spray for aphids on potatoes is prepared by adding 3 pounds of derris or cube root powder and 2 quarts of soybean oil to 100 gallons of bordeaux mixture. Substitute 100 gallons of water and 5 pounds of fish-oil soap for the bordeaux mixture if this mixture is not needed in either of

[26] See footnote 1, p. 6.

these sprays for the control of diseases. Dust mixtures containing 0.75 percent of rotenone are also effective against the aphids.

Nicotine sprays are poisonous and must be handled carefully.

Aphid populations on potatoes may be substantially reduced by applying DDT in the form of an emulsion, a spray suspension, or a dust mixture. For an emulsion use ½ pound of DDT in an oil base, plus an emulsifier, in 100 gallons of spray per acre application. Indications are that, although DDT emulsions are compatible with bordeaux spray, more satisfactory control of insects may be obtained when fungicidal sprays that do not contain lime are used. For a spray suspension use 1½ pounds of a wettable powder containing 50 percent of DDT, or its equivalent, in 100 gallons of spray per acre application. If the wettable powder contains less than 50 percent of DDT, then enough of the powder should be used to insure that at least ¾ pound of DDT is applied per acre application. More than 1½ pounds of DDT (3 pounds of 50-percent wettable DDT powder) does not appear to be necessary for use with copper sprays that do not contain lime. If bordeaux mixture is used, 2 pounds of DDT (4 pounds of 50-percent wettable DDT powder) appears to be desirable to offset any reduction in effectiveness due to the bordeaux spray. For a dust mixture use 35 pounds of a dust containing 5 percent of DDT per acre application, combined with a fungicide, and talc or pyrophyllite as the diluent.

Sufficient data are not available for basing recommendations regarding the number of DDT applications required for best results. Indications are that two thorough applications made at critical times in the insect infestation will reduce the population of aphids, as well as of the Colorado potato beetle and the potato flea beetle, and lead to increased yields. Best results are likely to be obtained when DDT is used in each fungicidal treatment. If this seems too expensive, the use of DDT in alternate treatments is suggested.

SEED-CORN MAGGOT

The seed-corn maggot (*Hylemya cilicrura* (Rond.)) is the immature, or maggot, form of a small fly that lays its eggs on soil and decaying vegetable matter. The small white maggots that emerge from the eggs feed on a wide range of substances, including both living and dead plant and animal life. Food preferences appear to be the sprouting seed and the seedlings of beans, corn, and peas. Their feeding on potato seed pieces in the soil is accompanied by decay and results in the seed piece failing to sprout or in a stand of weak plants. Apparently the seed-corn maggot always begins feeding on the cut surface of the seed piece, as it has never been known to enter through the healthy skin of the tuber.

The best control for the seed-corn maggot is to allow the potato seed pieces to heal, or suberize, before they are planted (fig. 21). For further information on the control of the seed-corn maggot as a pest of potato seed pieces, see Technical Bulletin 719, Prevention of Damage by the Seed-Corn Maggot to Potato Seed Pieces.

POTATO LEAFHOPPER

The potato leafhopper (*Empoasca fabae* (Harr.)) is important as a pest of potatoes because its feeding on potatoes causes a destructive disease known as hopperburn. This disease begins with a yellowing of

the leaf around the margin and tip, followed by a curling upward and rolling inward. The leaf changes in appearance from yellow to brown and then becomes dry and brittle. When the leafhopper infestation is heavy the entire plant may die prematurely.

The potato leafhopper is a small green insect, about one-eighth of an inch in length and wedge-shaped. It feeds from the under side of the leaves and sucks the juices of the plant. Leafhoppers are very active, and the first sign of infestation may be detected as one walks through the potato field and the small adults flit from plant to plant when disturbed. The lower surfaces of the leaves harbor the immature leafhoppers, which are similar in shape to the adults but are paler and do not have wings.

Leafhoppers and the resultant hopperburn can be controlled by spraying with bordeaux mixture or dusting with a dehydrated copper sulfate and lime mixture. The bordeaux mixture should be applied as soon as the adults appear, usually when the plants are 4 to 6 inches high, in areas where the insect is prevalent. Care should be taken to cover the under side of the leaves with the bordeaux mixture or with the dust mixture. Treatment should start with the first signs of the insect in the field; otherwise the bordeaux may not hold the pest in check. The potato leafhopper can be controlled with DDT by applying either a dust or a spray as directed for the Colorado potato beetle (p. 55).

WIREWORMS AND OTHER SOIL-INFESTING INSECTS

Potato tubers are often rendered unmarketable by small holes caused by the feeding of wireworms or by that of larvae of flea beetles, while larger scars may be caused by the feeding of white grubs. When the feeding scars are discovered, the insect that caused them is seldom to be found and it is difficult, therefore, to determine which one of a number of species is responsible. Wireworms make clean tunnels that are usually perpendicular to the surface of the tuber and are lined with a new growth of plant tissue. Flea beetles cause small pimplelike scars on the tuber and very small tunnels just below the skin. White grubs cause large holes that are usually irregular in shape and shallow.

No satisfactory methods have been found for the control of wireworms attacking potatoes in the northern potato-producing regions. Lands known to be infested by wireworms should be avoided for potato culture. The heaviest wireworm damage occurs usually in fields where potatoes are planted 2 or more years in succession. Fall plowing and crop rotation are suggested as means of reducing damage by wireworms and white grubs. Consult your local agricultural college for help in solving your control problem.

HARVESTING

The date of digging potatoes should be influenced largely by the condition of the crop. The tops should be dead, and the tubers should be thoroughly hardened so that the skin will not peel easily or bruise. Only when the market conditions are extremely good and the crop is for immediate consumption should potatoes be harvested when the tops are still green. Otherwise, spores of the late blight fungus still active in the living foliage may get on the tubers and cause rot in storage. To eliminate current-year infection by virus diseases, potatoes

Figure 38.—Hauling potatoes in barrels from the field to storage house.

for seed are sometimes harvested early, usually late in July or early in August before the disease-carrying insects become numerous. Seed harvested at this time should be handled very carefully and stored for at least 2 weeks where the temperature range is 50° to 60° F.

Another practice is to pull the tops and leave the tubers in the ground for at least 2 weeks for the natural maturing process during which the skin becomes toughened. Still another method consists in the use of certain chemicals applied to the foliage by suitable means.[27] Chemicals have been tried successfully in certain late-crop areas to kill the tops before too many oversize and hollow-hearted tubers develop; such tubers are especially apt to occur in seasons when growing conditions are at their best and killing frosts hold off late into the growing season. Growers have been finding that killing the green tops by means of chemicals not only arrests tuber development but makes digging and picking up the crop easier and faster and reduces late blight tuber infection to a considerable extent. Some discoloration of the tubers may result from the use of certain chemicals.

The harvesting season for most of the late crop of the North begins in September and extends into late October. The crop is harvested with the elevator type of digger hauled either by a pair of horses or by a tractor. The most satisfactory type of horse-drawn machine is equipped with a small gasoline engine mounted on the digger, which operates the carrier. The carrier in most cases should be continuous rather than have an extension elevator. The fall of the potatoes from the front elevator to the extension elevator accounts for a large amount of injury. The engine is equipped with an automatic clutch, which throws the engine out of gear when a rock or other obstruction is caught in the elevator. The speed of the engine can be regulated by the teamster. The tractor digger is equipped with a power take-off and a safety release clutch. Some two-row tractor diggers are used

[27] A number of commercial preparations for killing potato tops are on the market. Any potato grower interested in the subject should write to his State agricultural college for information and directions.

by large growers. These require an extra man in addition to the tractor driver.

Diggers should be set deep enough to provide sufficient earth to cushion the potatoes until they pass to the end of the elevator. On very light, dry soils where the soil falls through rapidly, the speed of the elevator should be reduced by change of gears, and the agitators bearing the elevator chain should be replaced with rollers. Methods of handling potatoes after they have been dug vary with the locality. In Maine, the tubers are picked up in baskets from which they are dumped into barrels and hauled to the storage house (fig. 38). The empty barrels are returned to the field. In most sections of the Northeast the potatoes are picked up in slatted crates, hauled to the storage house, and either stored in the crates or dumped into bins (fig. 39). Handling in crates is preferable to that in barrels because less bruising results. Careful handling of the crop at harvesttime will be found to pay good dividends.

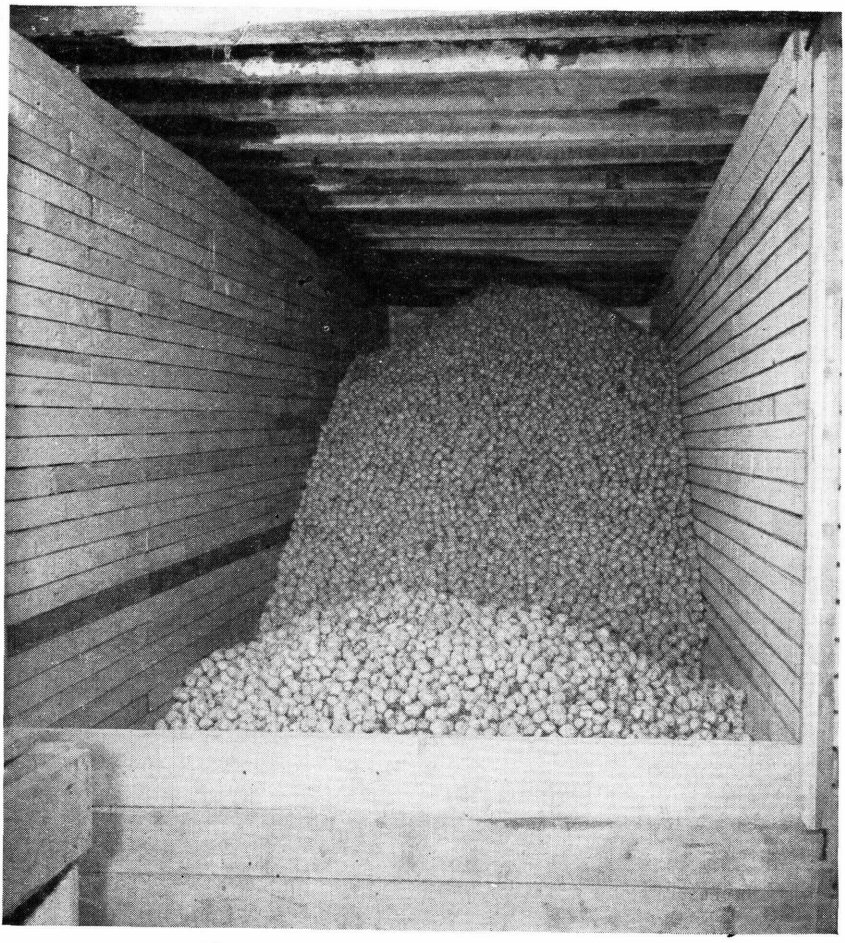

Figure 39.—Potato-storage bin partly filled.

Figure 40.—Track-storage potato houses at Caribou, Maine.

STORAGE [28]

In the Northeastern and North Central States where potatoes are produced on a commercial scale the problem of storage is important, as it is practically impossible as well as economically undesirable to attempt to market the entire crop in the autumn immediately after it is harvested. To insure a uniform supply throughout the winter, storage must be provided on the farm or at the shipping station (fig. 40) for 65 to 75 percent of the total crop. Commercial growers should make provision to store at least 75 percent of their crops, and often it would be convenient to store the entire crop. Types of storage places employed vary with the quantity to be stored and the length of the storage period. Filled pits or dwelling-house cellars may be used for smaller quantities or for emergency storage. However, where large quantities are to be stored or the potatoes are to be held late in the spring, common types of storage include root cellars and above-ground structures of various types (fig. 41). The cost of a conveniently arranged and well-insulated storage house will often be repaid by the saving of labor in handling the crop and the ability to hold potatoes with little loss until late in the spring. Each grower must determine for himself which of these types of storage house is within his means and best meets his requirements.

For information as to details of construction and matters pertaining to storage-house management see Farmers' Bulletin 1986, Potato Storage, and Technical Bulletin 615, Studies of Potato Storage Houses in Maine.[29]

The storage house or cellar should be in a well-drained location. It should be well insulated to keep the potatoes from freezing and to control humidity. It is important that the ceiling or roof have enough insulation to prevent condensation of moisture, which may

[28] Prepared by R. C. Wright, physiologist, Division of Fruit and Vegetable Crops and Diseases.

[29] Out of print, but may be consulted in libraries.

drop back on the tubers and predispose them to decay. The storage house should be so designed that potatoes can be put in and removed with a minimum of labor and of damage due to bruises and cuts. Daylight should be excluded as it causes greening, which injures the quality of table stock. In sections that have a relatively mild climate it is not usually advisable to store potatoes in bins more than 5 or 6 feet deep. When the weather is cool at digging time it may be safe to store potatoes 12 feet deep in the bins, but before spring the depth should be reduced if potatoes are to be held late.

A continuous space for air circulation should be provided between the bins and the outside walls and between the bottom of the bins and the main floor. The air circulation thus afforded, due to the warmer air rising in the storage and then passing down along the outside walls, will protect the potatoes from frost damage. At times a stove may be needed for additional protection. Provision should be made for the entrance of fresh air, and the intake should preferably be near the stove so that the air will be warmed and not injure the nearby potatoes. Ventilators must be provided for cooling the house when weather conditions require it. The manipulation of the ventilators is highly important and requires close attention.

Usually ventilation is only for the purpose of lowering the storage-room temperature. Unnecessary ventilation may cause undue shrinkage and an excessive loss in tonnage of stored potatoes. Ventilators should never be opened when the air temperature is higher outside than inside, as this may cause sufficient condensation throughout the building to wet the potatoes and thereby cause increased decay and also undue deterioration of the building and equipment. The relative humidity should be kept at 85 to 90 percent.

The tubers should be dry and reasonably free from dirt when stored. If excess dirt accumulates within the bin or under the slatted floor, air circulation is hindered. All rotted, bruised, and badly cut tubers,

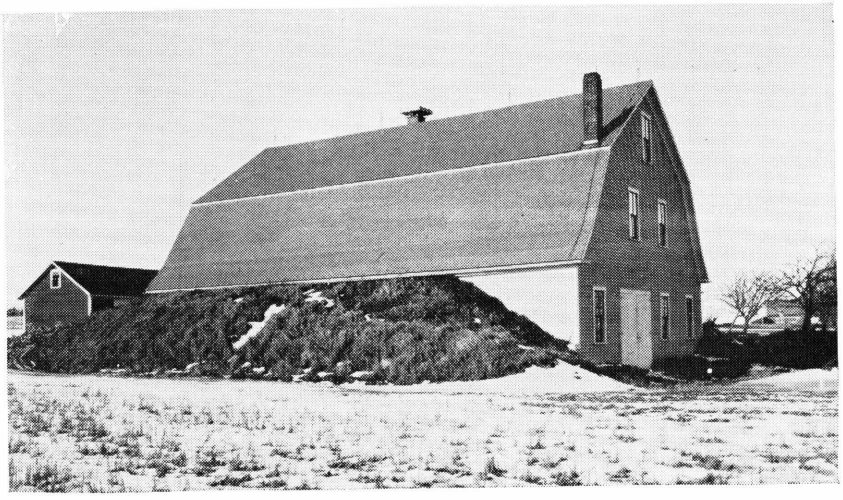

Figure 41.—A good type of potato storage house.

as well as those that are badly scabbed, should be carefully culled before the crop is stored.

If ventilation is restricted during the first 2 or 3 weeks of storage so as to hold the potatoes at about 55° to 60° F. and in the high atmospheric humidity that prevails in a bin of freshly dug potatoes, the normal shrinkage can be reduced about 20 percent. This is due to the healing of cuts and injuries that occurs under favorable temperature and humidity conditions. Furthermore, potatoes receiving this preliminary treatment seem to retain better cooking quality than if the storage temperature is lowered immediately. A low temperature at the beginning of the storage period is not necessary because the tubers are then in a state of dormancy.

After this curing period, temperatures may be lowered; 38° F. is desirable for the storage of seed potatoes, since at this temperature they will not sprout; 40° or slightly higher is better for table stock.

Potatoes stored at 50° to 60° F. have better cooking quality, especially for making chips, because they contain less sugar than those stored at lower temperatures. In this higher temperature range, however, sprouting will occur in a shorter time. Although a limited amount of sprouting does not injure potatoes for food purposes, sprouted stock shrinks in weight and is difficult to market. Sprouting can be checked by lowering the storage temperature. Potatoes stored at 40° are acceptable for most purposes but not for chip making. Such potatoes, however, can usually be improved in cooking quality by being held at 60° or 70° for about 2 weeks before they are used. This permits some of the sweetness to disappear. At all times tubers should be protected from extremes of heat and cold.

Potatoes stored throughout the winter under conditions meeting the requirements suggested in the preceding paragraphs should not shrink more than 5 percent, and under especially good conditions they may shrink only 3 to 4 percent. Assuming that 5 percent represents the average loss under good storage conditions and 20 percent that under poor conditions, the actual loss sustained by the grower or dealer on 300,000 pounds of potatoes would in the one case be 15,000 pounds and in the other 60,000 pounds; or, at $2 per hundredweight, a loss of $300 would result under good storage and of $1,200 under poor.

GRADING AND MARKETING

It is distinctly to the advantage of the potato grower, or for that matter of anyone offering potatoes for sale to the consuming public, to see that the potatoes present a good appearance. To accomplish this is good advertising for the potato industry. Potatoes having cuts, bruises, and insect or disease injuries neither sell well nor command a premium price. Such potatoes should be removed so that the consumer will not suffer loss in preparing them for the table and so that consumer prejudice will not develop against potatoes in general. Potatoes of undesirable size or shape and with excess dirt also should be removed before marketing is attempted. Only in this way can the individual grower hope to build up a reputation for good table stock and can any potato-producing region hope to establish a good reputation for its product. For complete information on marketing the late crop, see Circular 475, Marketing the Late Crop of Potatoes.

The United States Standard for Potatoes,[30] issued September 1941 by the United States Department of Agriculture and made effective June 1, 1942, fully describes potato grades as officially designated, the tolerances for defects pertaining thereto, and presents a definition of terms as used in the prescribed standards. Copies of the latest United States Standards for Potatoes may be obtained from the United States Department of Agriculture, Washington 25, D. C.

PRODUCTION CENTERS AND VARIETIES GROWN IN THE SEVERAL STATES

To assist the reader in acquiring general information about the potato industry in the different Northeastern and North Central States certain features relative to potato production in each State are discussed. Additional information may be obtained from the State agricultural college.[31]

CONNECTICUT

Connecticut produces approximately 3,000,000 bushels of potatoes a year, chiefly of the Green Mountain variety. Most of these are grown commercially in the western to northwestern parts of Tolland County and in the eastern part of Hartford County. Recently there has been considerable development in the vicinity of Putnam in Windham County. Irish Cobbler is grown commercially to some extent in the New Haven-Bridgeport district and in other parts of Fairfield and New Haven Counties. The newer varieties Chippewa and to a less extent Katahdin and Sebago are replacing Green Mountain in part largely because it is difficult to obtain first-class Green Mountain seed stock. The newer varieties are reported to yield well and to find a ready market in the hotel and restaurant trade because they have thin skins, shallow eyes, and a pleasing appearance and hold together well after being boiled or steamed. In the southern districts potatoes are planted as early as April 15 to 20 and in the northern ones between May 1 and 15.

ILLINOIS

In Illinois there are no districts in which a surplus of potatoes is produced. The districts of lowest production are usually near the centers of population and where soil conditions are not favorable for potato growing. Potato imports into the State amount annually to about 25,000,000 bushels. The bulk of the potato crop grown in Illinois is concentrated in the three northern tiers of counties and in three counties near St. Louis, Mo. The principal early variety is Irish Cobbler. Triumph is losing favor in Illinois because of its extreme susceptibility to leafhoppers. Late varieties are Rural New Yorker No. 2, Russet Rural, Katahdin, and Sequoia; the last-named is used especially because of its leafhopper tolerance. The early varieties are planted in late March or early April, depending on weather conditions. May 15 to June 1 is satisfactory for planting late varieties.

[30] See United States Standards for potatoes, effective June 1, 1942. U. S. Dept. Agr., Agr. Market. Admin. Serv. and Regulat. Announce. 151, 1941.

[31] The authors acknowledge the helpful cooperation of agricultural experiment station and extension service workers who furnished information on potato varieties, dates of planting, and other pertinent facts for the individual States.

INDIANA

The main commercial acreage of potatoes is grown on muck in northern Indiana. Most of the acreage is planted to Irish Cobbler, Chippewa, Katahdin, and Sebago. The acreage of Irish Cobbler is decreasing, whereas that of Sebago is increasing because of its resistance to common scab. Loss from common scab is severe in many mucks, although it has been found that in this area early planting (first week in May) reduces the amount of this disease and increases yields. Because of good local demand in most localities small areas of commercial potatoes are scattered over most of the State, particularly along the Ohio River, where Irish Cobbler and Katahdin are chiefly grown. Sequoia, however, shows promise on some upland soils where common scab is not a problem.

IOWA

Iowa does not produce enough potatoes to supply its own needs, although from 1940 to 1943 about 55,000 acres of potatoes, most of which were used on farms or sold on the local markets, was grown. Commercial potato production is confined very largely to the peat lands in the north-central part of the State, where production is very satisfactory. Irish Cobbler and Sebago are considered the best varieties for Iowa conditions. Early Ohio is grown to some extent, but it is likely to produce knobby tubers and those with growth cracks; it does not yield as well under adverse conditions as Irish Cobbler does. Rural New Yorker No. 2 and Russet Rural may be grown with fair success, but they mature late and do not produce satisfactory yields. Potatoes are planted in southern Iowa about April 1 and in northern Iowa from April 15 to 20. On peat or muck in northern Iowa, where most of the commercial crop is grown, the planting season usually ranges from April 20 to 25.

KANSAS

In Kansas, one of the intermediate potato-growing States, potatoes are grown commercially principally in the Kaw Valley, including Wyandotte, Johnson, Leavenworth, Douglas, Jefferson, Shawnee, Pottawatomie, Riley, and Wabaunsee Counties. The principal variety of potato in Kansas is Irish Cobbler. Triumph, Red Warba, and Warba are also grown. The main commercial crop is planted between March 15 and 31 and is generally harvested between June 25 and July 20. In western Kansas, principally in Scott and Grant Counties, a small acreage is grown under irrigation; this is planted in April and harvested in July and August. Very few potatoes are grown commercially as a late crop but, when so grown, they are planted in late June or early July.

MAINE

Maine has led the United States in potato production, including production of certified seed, for the past 20 years. All but approximately 15 percent of the crop is produced in Aroostook County, the northernmost county in the State. The farming land in Aroostook County lies in a narrow belt, from one to three townships wide, along the eastern and northeastern part of the State. The temperature throughout the growing period is very favorable for potato production. During the growing period 12 to 18 inches of rainfall is essential for good yields. Planting in Aroostook County begins as soon

as the soil can be fitted, and the planting season ranges from about May 10 to the end of May or early June. In the southern part of the State planting begins 10 days to 2 weeks earlier.

Irish Cobbler is the principal early variety of commercial importance in Maine. Triumph and Spaulding Rose are grown only to a very minor extent. Green Mountain is the leading late variety, but the acreage is on the decrease. The older varieties are being replaced by Katahdin, Chippewa, Sebago, and Houma.

MASSACHUSETTS

Massachusetts produces about one-third of the potatoes required for consumption in the State. Soil and climatic conditions are not particularly favorable for large potato yields, and costs of production are apt to run too high. Other crops can be produced at a better profit. Irish Cobber is the principal variety. At present Green Mountain is the leading variety for a late crop, but Katahdin is a very close second. Sebago acreage is increasing somewhat. Along the Narragansett Basin planting begins in early April, progresses to the Connecticut Valley and districts of low altitude, and ends in the hill districts of western Massachusetts, where June planting predominates.

MICHIGAN

For commercial potato production Michigan is divided into four districts: The eastern district largely produces table stock and is located in the east-central part of the State, in Oakland and Lapeer Counties and adjoining ones; the western district, also a table-stock producing district, extends north from Kent and Montcalm Counties and includes Wexford and Missaukee Counties; the northern district comprises the northern counties of the Lower Peninsula; and the fourth district is the Upper Peninsula. In the Upper Peninsula the majority of the potatoes are planted after May 20 and in the Lower Peninsula from June 1 to 15.

On muck in the southern part of the State there has been a gradual acreage increase of potatoes. The Upper Peninsula has had an increase in potato acreage, whereas the acreages in other districts have remained the same or have decreased.

The best late varieties that are grown in Michigan are Russet Rural, Sebago, and Menominee; medium early, Chippewa, Katahdin, and Pontiac; and early, Irish Cobbler.

MINNESOTA

Minnesota has a number of potato-growing districts. In the Red River Valley and adjacent upland districts in the northwestern part of the State, Irish Cobbler, Triumph, and Early Ohio, and to a less extent White Rose, Warba, Pontiac, and Chippewa, are grown for either seed or table stock. On the high-lime peats the largest concentration of acreage is on the Freeborn County bogs with numerous smaller concentrations at widely scattered localities; Irish Cobbler is the principal variety grown. In an early district, lying adjacent to Minneapolis to the west and north, Irish Cobbler, Early Ohio, Warba, and Pontiac are the principal varieties. On the uplands in the district east and north of the Mississippi River both early and late varieties are adapted. In addition to the varieties mentioned, Chippewa, Green Mountain, Russet Burbank, and Sequoia are also grown. The pro-

duction is for both seed and table stock; Minnesota ranks third in the United States in certified-seed production. In the southern half of the State planting begins about April 15, in the peat bogs about May 15, and in the northern half of the State about May 15, continuing during the first week in June.

MISSOURI

Soil and climatic conditions in Missouri, one of the intermediate States, are reported as not being particularly favorable for growing late-crop potatoes. Irish Cobbler is the principal variety grown; others are Triumph and Red Warba. There is no immediate prospect of any of the newer varieties replacing Irish Cobbler in the commercial growing districts, but a need is being felt more and more for an early variety that is more resistant to common scab.

Potatoes are planted as soon as the land can be prepared in the spring; the time varies from March 1 in southern Missouri to April 1 in the northern part of the State. Most of the commercial acreage is in west-central Missouri and on the Missouri River bottom land, where planting takes place about March 20.

NEW HAMPSHIRE

New Hampshire grows fewer potatoes than are consumed in the State. The principal varieties grown are Chippewa (8 percent) and Irish Cobbler (3 percent) for the early crop and Green Mountain (55 percent), Katahdin (15 percent), Sebago (15 percent), and Houma (4 percent) for a late crop. According to the New Hampshire Agricultural Experiment Station, the production of Green Mountain is decreasing somewhat because of its susceptibility to net necrosis; the production of Katahdin, Sebago, and Houma is increasing. Chippewa is being produced as the early crop in southern New Hampshire almost to the exclusion of Irish Cobbler. In southern New Hampshire the first planting dates range from April 25 to June 15 and in northern New Hampshire from May 5 to June 10.

NEW JERSEY

New Jersey is another of the intermediate potato States. Approximately 85 percent of the crop is planted between March 20 and April 30. Commercial harvest generally starts about July 15 and continues until October 15. The peak of shipments is usually reached between August 15 and September 15. A few potatoes are stored and sold during November and early December. Approximately 75 percent of the acreage is produced in the three central counties: Monmouth, Middlesex, and Mercer; considerable acreages are also grown in Burlington, Cumberland, and Salem Counties. The principal varieties grown are Katahdin, 50 to 55 percent; Irish Cobbler, 30 to 35 percent; Chippewa, 10 to 15 percent; and Green Mountain, 3 to 4 percent.

NEW YORK

New York ranks third among the potato-producing States, being exceeded by Maine and Idaho. Commercial production is centered mainly in the following three sections: (1) Long Island, including Suffolk and Nassau Counties, where the most intensive methods, the largest acreage units, and the highest acre yields are found. A long, temperate growing season, a friable soil, and nearness to the New York

City market make Long Island an ideal district for potato growing. The important varieties here are Green Mountain, Irish Cobbler, Chippewa, and Katahdin. Planting begins in late March and early April. (2) Western and central New York, including in order of rank in production Steuben, Genesee, Erie, Wyoming, Monroe, Wayne, Onondaga, and Allegany Counties. The approximate order of importance of the principal varieties in this large section is Katahdin, Sebago, Rural New Yorker No. 2, Russet Rural, Chippewa, and Houma. Much of the soil in this section is not ideal for potatoes; hence a wide range of varieties is grown. About 9,000 acres of potatoes is grown on muck in western New York, the larger acreages being in Wayne, Genesee, Orleans, Madison, Livingston, and Steuben Counties. Katahdin, Chippewa, Irish Cobbler, Green Mountain, and Warba are the most popular varieties for muck lands. On the uplands soils of this section planting usually begins about May 1 and extends to June 15; on the muck farms planting is about 1 month earlier. (3) Northern New York, including Franklin, Clinton, and Essex Counties. Being farthest north, Franklin and Clinton Counties have an ideal climate for potatoes. Considerable certified seed is produced in this section, principally in Franklin and Clinton Counties. However, the growing season is shorter than elsewhere in the State; so growers plant as early as possible and of necessity plan to harvest before damaging freezes occur in September. The soils are on the foothills of the Adirondack Mountains, are mostly of a well-drained, sandy-loam type, and produce a crop of very high culinary quality. The principal varieties are Green Mountain, Chippewa, and Irish Cobbler.

NORTH DAKOTA

Triumph, Irish Cobbler, and Early Ohio lead in production in North Dakota. In special localities small acreages are being devoted to the growing of Red Warba, Pontiac, and a number of the newer white varieties by the producers of certified seed for the seed trade in the Southern States.

Potato production in North Dakota is confined largely to the counties in the northern half of the Red River Valley and to local areas in the counties extending across the northern half of the State. North Dakota ranks second in certified-seed production in the United States. Most of the certified seed is produced either in the Red River Valley, particularly in the northeastern part of the State, or along the Canadian line in the extreme northeastern part of the State.

Planting dates range from the last week in April to the first week in June, but most of the planting is done during the second and third weeks in May. Much of the harvesting is done during the month of September.

OHIO

The best potato soils of Ohio are deep muck, sandy loam, and well-drained silt loam. The acreage of these soils is not extensive; hence Ohio produces only sufficient potatoes to supply the local demand from August through November.

The principal variety is Irish Cobbler. It is planted in southern Ohio as soon after March 20 as possible and in northern counties about April 20. Late varieties are planted at any time up to the middle of June, but the best average date is about May 25. Standard

late varieties are Katahdin, Sebago, and Russet Rural. Growers are urged to test out the newer ones, particularly Erie, Pontiac, and Sequoia. Sequoia is recommended as a late variety for home gardeners and others who are not well equipped to spray.

Foliage diseases are not as serious in Ohio as farther north. On the other hand, flea beetles and leafhoppers are very serious. Spraying to control these insects is essential in commercial production.

PENNSYLVANIA

The three leading counties in potato production in Pennsylvania are Lehigh, Lancaster, and Somerset; seed is produced chiefly in Potter County. Comparatively few early potatoes are grown, chiefly in the southeastern part. According to a preliminary estimate for 1945, the leading variety planted in Pennsylvania is Katahdin, followed by Russet Rural, Sebago, Irish Cobbler, and Rural New Yorker No. 2. Green Mountain is grown only to a slight extent.

Planting is done as early as conditions are favorable, usually about April 1 to 10. The late crop in northern Pennsylvania is planted from June 1 to 5; in central Pennsylvania, May 15 to June 1; and in southeastern Pennsylvania, May 1 to 15.

RHODE ISLAND

Rhode Island has a favorable climate for growing potatoes, and a number of soil types found in the State are especially suited to the crop. The markets are close at hand. Rhode Island production, however, equals only half the quantity consumed in the State. Irish Cobbler and Chippewa are the principal early varieties and Green Mountain the principal late one. Early varieties contribute about 40 percent and late varieties 60 percent of the potato acreage. The Katahdin and Sebago varieties are increasing in production. Planting begins late in March and usually is completed by May 31, depending on the location and the season.

SOUTH DAKOTA

In South Dakota commercial potato production is centered in Codington and Clark Counties and adjacent ones in northeastern South Dakota. In that section nearly 10,000 acres of certified seed stocks is grown; the seed is sold largely to growers in the Southern States and in Cuba.

To meet the demand of the southern growers early red varieties are preferred for seed-stock production. Triumph is the leading variety, Irish Cobbler is second, and Pontiac is coming into production. Although the acreage of Early Ohio is declining, it is third in seed-stock production and is still commonly grown in home gardens. Limited acreages of Chippewa and Katahdin are planted.

Planting dates vary from the middle of April in the southern part of the State to early May in the northern part. Late planting is restricted primarily to home gardens in the northeastern part of the State.

VERMONT

Potatoes are grown to some extent through all parts of Vermont. However, the heaviest commercial plantings are now made in the northeastern section with sizable production in some scattered points

farther south. Few are grown commercially in the Lake Champlain bottom lands.

Green Mountain has long been the leading variety, but in recent years it has become less popular because of its susceptibility to leaf roll and net necrosis. Of the new varieties taking its place, Katahdin, Houma, and Sebago are most popular.

In general, the planting dates in the northeastern section range from May 10 to 30 and in the southern section from about May 1 to 20. In some seasons, although rather rarely, planting must be delayed until June 1 or later. Growers are finding that early planting results in larger yields and better quality.

WEST VIRGINIA

In West Virginia there are no districts where potatoes are grown intensively. The bulk of the acreage is scattered in districts where growing conditions are particularly suitable. Preston, Tucker, Randolph, Nicholas, and Pocahontas Counties produce most of the main-crop potatoes.

Irish Cobbler, which makes up the bulk of the early crop, is grown in the Ohio and Kanawha River Valleys. Planting is usually done in early March. Some Irish Cobblers, as a second crop, and the late or main-crop potatoes, consisting of both Rural New Yorker No. 2 and Russet Rural, are grown in the intermediate and higher altitudes. According to the West Virginia Agricultural Experiment Station, Sebago and Katahdin are being used more and more for the main crop, probably because of the increasing difficulty in procuring certified "Rural" seed. Sequoia is popular with home gardeners who have inadequate means to control efficiently insect pests. The planting dates range from April 15 to June 1.

WISCONSIN

In Wisconsin there are three main-crop potato-production districts: (1) Southeastern Wisconsin, including the Racine-Milwaukee district, where the principal varieties grown are Irish Cobbler, Katahdin, Chippewa, and Russet Rural. Most of the planting is done in May. (2) Central Wisconsin, where Irish Cobbler is the principal early variety and Russet Rural and Katahdin are the principal late ones. The early varieties are planted in May and the late ones about June 15 to 30. (3) Northern Wisconsin, where the early varieties are Irish Cobbler and Triumph; late varieties, Katahdin and Chippewa and, to a much lesser extent, Green Mountain. Recently the Sebago has been recommended by the Wisconsin Agricultural Experiment Station as a promising late variety because of its resistance to yellow dwarf and to late blight of the foliage and tuber. Early and late varieties are planted in late May and early June.

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